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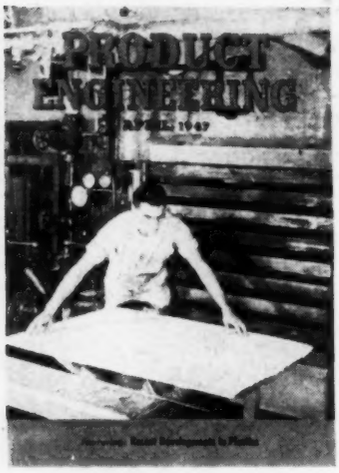


FRONT COVER

Layup of fabrics and cellulosic plastics being made ready for laminating in a hydraulic laminating press. First plant set up by Hercules Powder Company to manufacture new cellulosic thermoplastic laminates is located in Parlin, New Jersey. Kodachrome courtesy of the Hercules Powder Company.

Recent Developments in Plastics and Rubber

Postwar developments in new materials, new production techniques, and new fields of application are evaluated in a 32-page special report beginning on page 113. Subjects covered include polytetrafluorethylene, modified styrenes, plastics-rubber combinations, silicones, molded pulp resins, molded nylon, foamed plastics, honeycomb and sandwich constructions, low pressure molding and laminating, thermoplastic laminates, polyethylene, synthetic rubber, cellulosic plastics, annealing of polystyrene, thermosetting extrusion, and new applications for vinyl plastics.

Development Department Organization

How does the development department of a large company function, what is its purpose and how is it controlled? On page 81, R. D. Gartrell, Development Manager, Passaic Plant, United States Rubber Company, describes the development department of the Mechanical Goods Division of the United States Rubber Company and shows how this department is related to other departments in the organization.

Integral Horsepower Single-Phase Motors

Single-phase integral horsepower motors are increasingly powering medium sized home freezers, heat pumps, air or refrigeration compressors, ventilating fans and water pumps. Beginning on page 150, M. E. Cutten, General Electric Company, discusses how, when and where to use single-phase 1 to 10 horsepower motors, including basic steps in matching machine and motor characteristics. Various types of motors are explained.

Diaphragm Control Valves

Engineers interested in control valves will find the article on page 85, by Bruce A. Irwin, General Sales Manager, Hammel-Dahl Company, of great significance. This article sets up a system of preferred numbers which have been tied in with type sizes that do not correspond to preferred numbers. Mr. Irwin also sets up formulas, computation and designs of systems that are controlled by a diaphragm control valve.

Ball and Roller Bearing Seals

Engineers have found that often the exclusion of dirt and water from ball and roller bearings is far more important than the retention of lubricant in the bearing. E. P. Stahl of the Garlock Packing Company, see page 103, tells why and discusses several designs of seals that insure maximum protection of the bearing from grit, sand, mud and water.

Magnetic Recording Flaw Detector

Detection of cracks or other flaws on or near the interior surface of hollow parts is difficult because of the inaccessibility of the surfaces. C. H. Hastings, Watertown Arsenal, see page 110, describes the basic principles and operation of a newly developed flaw detector that measures and records magnetic leakages caused by the presence of flaws in ferrous materials.

Torsional Deflection of Hollow Shafts

Relations between the torsional deflection, outside diameter, applied torque, and lengths of hollow shafts loaded in torsion, can be obtained from the chart prepared by Victor M. Kibardin, Consulting Engineer, appearing on pages 171 and 173.

Plating Nonferrous Base Metals

The largest family of nonferrous materials requiring plating is the copper bearing group including pure copper, brass, or bronze. On page 155, P. W. Prouty, Westinghouse Electric Corporation presents part II of a discussion of common industrial electroplates and their application.

MAY HIGHLIGHTS

Speed Control of Fractional Horsepower Motors, by W. M. Yogerst, Bodine Electric Company. Discussion of performance and application factors of half dozen different methods for controlling speed of small motors.

Stainless Spring Steels, by Harold C. R. Carlson, chief engineer of the Chas. Fischer Spring Company. Presents information and data about stainless steel for springs in easy reference form.

Induction Hardening, by Russell H. Lauderdale, Northern Ordnance, Inc. Five basic requirements for satisfactory application of induction hardening process and information on proper selection and processing of steels for getting most from this relatively new method.

Fluid Motion in Pipes, by A. H. Korn. Basic equations for calculating pressure drop of fluids and gases flowing in pipe lines.

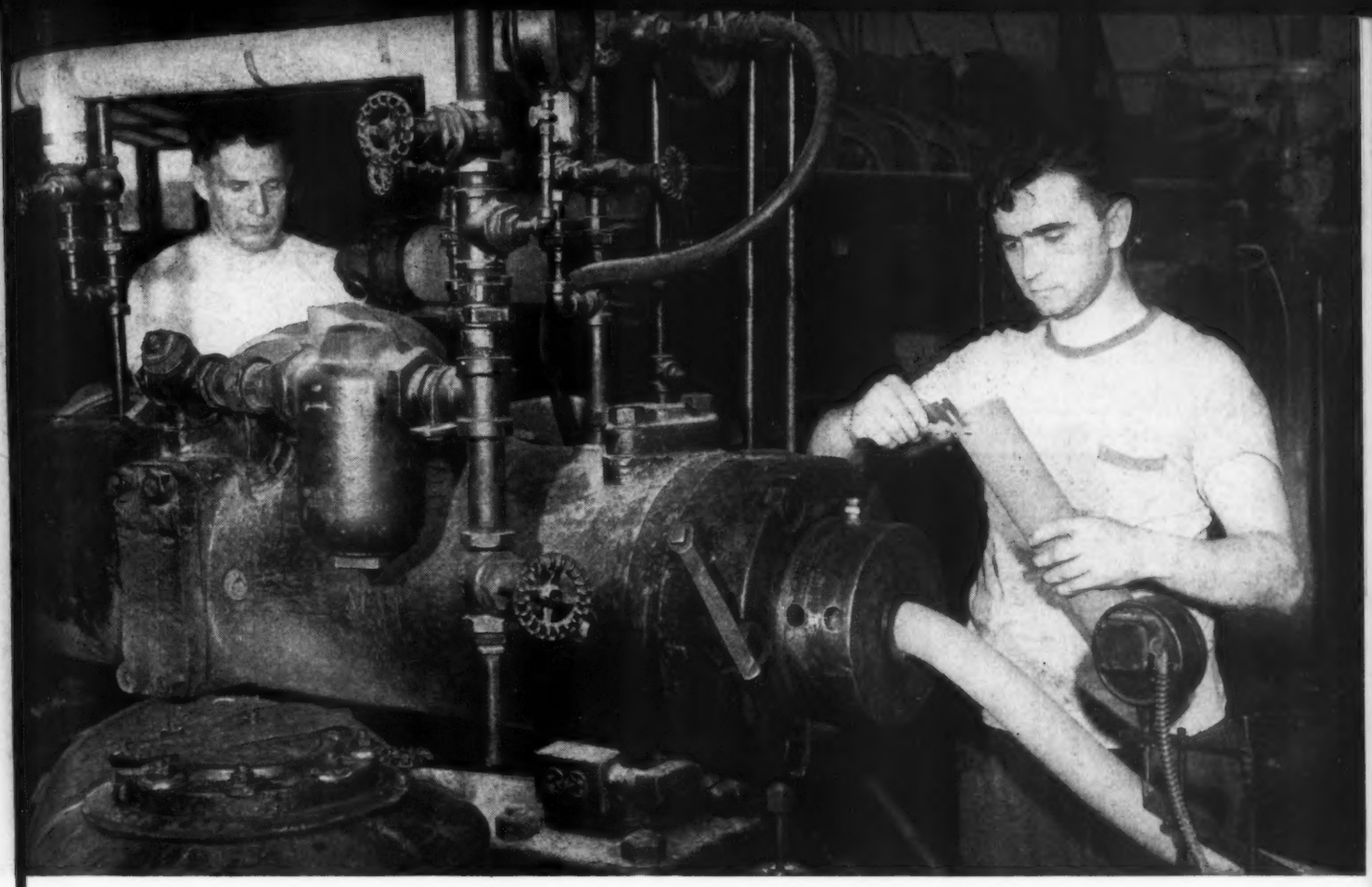


Fig. 1—GR-S rubber stock being extruded from a tuber to the required diameters prior to slicing into jar rings.

Purpose and Organization Of a Development Department

R. D. GARTRELL
Development Manager, Passaic Plant, United States Rubber Company

ALTHOUGH the main business of the author's Company is the manufacture and sale of rubber goods, its Development Department has a parallel in every progressive company, large or small. The Development Department does not enter directly into either the manufacture of rubber products or the sale of them. It is a service department, the Production and Sales Departments being the principal departments served. Its work achieves no useful purpose unless the goods made by the Production Department and sold to the customer by the Sales Department reflect better quality or lower cost. To attain these objectives close cooperation of these three departments is necessary. Fig. 2 shows the administrative relationship of these departments within the company organization.

In order that the Sales Department bring in a high volume of profitable orders, a factory engaged in the manufacture of consumer goods must supply goods to sell:

1. Of a suitable variety;
2. At the right price;
3. Of satisfactory quality;
4. And at the proper time.

The Development Department has a great deal to do with making available a variety of quality goods at salable prices. It often has responsibility too that goods are developed in time to take advantage of pending markets.

Availability of a satisfactory variety of goods is the achievement of past efforts on the part of Research, Design, Development and Production Departments. Unfortunately, or fortunately, a line of merchandise does not remain static. Old lines become obsolete and new ones have to be added if volume of sales is to be maintained. Most companies are not content merely with holding current sales volume. If expansion and progress are goals, new products are a neces-

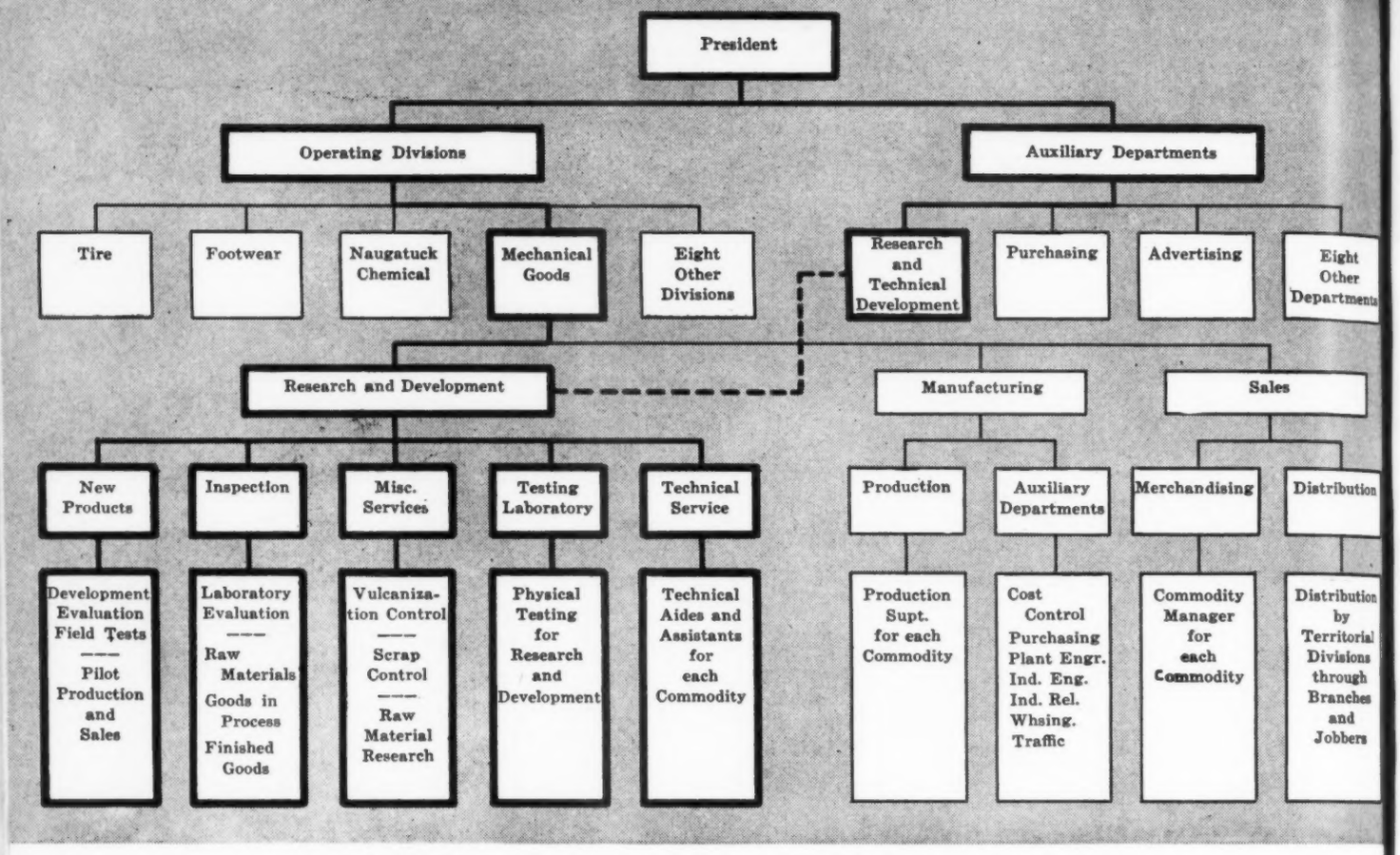


Fig. 2—Relation of the Development Department to the operating divisions and the other departments in the organizational structure of the Company.

sity. New products come about in various ways.

The Sales Department by virtue of close contact with customers and their requirements, is in a position to suggest new products. The salesmen can report trends in their customers' business, the demands for new articles and desirable modifications of old ones.

To get ideas on which to work is the most difficult part of all development work. Once the idea has been proposed, the obstacles in the path to its achievement may be difficult but at least there exists a definite goal to shoot at. An example will illustrate how the Sales Department brings in new ideas. Several years ago, the Pullman Company started building streamlined trains. Objection was raised to the open space between the cars in that the recession broke up the single-unit appearance of the train. The old convas diaphragms or bellows covering the passageway never looked streamlined. The Sales Department became aware of this need, possibly because rubber was the only material with enough stretch to take care of the distortion when going around curves. With this as a starting point, diaphragms were developed and have now become standard on all streamlined trains.

Another example of how the Sales Department helps provide a suitable variety of goods can be taken from the present status on hydraulic hose. Because of early pioneering in the development of high pressure hose for hydraulic work, stocks of hydraulic hose have a fairly wide range of types at the present time. During the war, the use of hydraulically actuated devices grew rapidly. Such devices were used for all sorts of applications, many of which proved to be satisfactory. Under this impetus, these devices are now being applied generally for peacetime uses. It is the responsibility of the Sales Department through customer contacts to observe and report this trend.

Progress in the design of new hydraulic devices is being followed carefully, as the chances are great that additional types of hose and accessory rubber parts will be evolved. As this happens further new items will be added to the hose products now available.

In regular day-to-day work, the men of the Sales Department encounter the needs for rubber parts for new equipment that some customer either plans to make or is making. These requests come into the factory in the form of inquiries. Fig. 3 is a typical inquiry. Many inquiries can be answered by re-design or new applications of mechanical goods already available so that little development is required. Others may require research as well as development.

At present about 1,500 inquiries are received each month. Usually the item called for is specific in its application. It may or may not be suitable for many customers. Even when an article is developed for a single customer, valuable ideas for other applications frequently accrue from the efforts. Most of the items are new in the sense that this company has never made them before.

Many new varieties of goods originate in the Development Department. This often comes about through a study of new raw materials. Numerous examples can be cited. The discovery of types of synthetic rubber led to new and better articles for diverse applications. When natural rubber comes in contact with gasoline, oils, or greases, it swells and eventually tends to disintegrate. Neoprene

and the Buna-N types such as Perbunan, Hycar, and Chemigum swell only slightly under these conditions and do not disintegrate. These types opened out a whole new field for rubber parts, molded goods, hose, packing and belts. Other applications for them are found daily—places where natural rubber could not be used at all, or in places where the use of natural rubber was only partially satisfactory.

Fabric in some form is second to rubber in importance in the manufacture of rubber products. In recent years, synthetic fibers have become available, such as rayon, nylon and glass fiber. Improvements have been made in cotton, such as the treatment that produces "Ustex," which is registered in the U. S. Patent Office. Ustex is so different from natural cotton that it can be considered a new material. "Asbeston," also registered in the U. S. Patent Office, is a new asbestos fabric. An old fiber, so old that it may be considered new, called ramie, is just making its appearance.

Ramie has long been known as a material that looks like hemp. It has exceptionally high strength and resistance to rotting. The difficulty in the past has been that no one knew how to process it to obtain a suitable yarn. This appears to have just been achieved. Rayon is stronger than cotton and is not affected by heat to the same extent as cotton; but rayon swells and loses strength when wet. Nylon is several times stronger than cotton and has much more stretch. Ustex is stronger than cotton and has less stretch. Glass fiber is also stronger than cotton and is not affected by most chemicals. Asbeston has relatively high strength and is heat resistant. So it is that new materials are developed into new and better varieties of goods to sell. Many have already been developed and others will appear from time to time.

The General Research Laboratories are another source of new rubber products. Much of the research is not directed toward developing specific products, though at times such products are made in developing new processes. Cellular rubber, a hard or soft bond cell sponge in board form, and "Hydron," an absorptive liner for concrete forms, were worked out from information obtained from the General Laboratories. Hydron is registered in the U. S. Patent Office.

Still another source of new varieties is the discovery of new process methods. In searching for a better and faster method of making gas-mask corrugated tubes for the Army, a new process was discovered that, though never used in making gas-mask tubes, led directly to "Multi-Flex" ducts, another product that is registered in the U. S. Patent Office.

Keeping the established line of goods up to date is equally as important as the development of new products. To this end monthly meetings of representatives of the Sales, Production and Development Departments are held at which the good and bad qualities of each product are reviewed and improvements proposed. The Sales Department presents data on volume and trend of sales, new needs for a specific article, customer criticisms, and information about competitive products. Another responsibility is to propose definite changes that will improve the product from the customer's viewpoint.

The Production Department supplies data on present production costs of the product under discussion and an estimate of the production costs of the improved product. The Development Department investigates new processes and proposes improvements in manufacturing methods to get the kind of product desired by the customer.

Decisions made at these meetings are preserved in minutes of the meeting. They are binding on the three departments. All three have a hand in setting up the program of work

MECHANICAL GOODS DIVISION

IMPORTANT
Incomplete or improperly filled out inquiries will be **returned without quotation.** If necessary use other side rather than a letter.

Branch Atlanta
Inquiry No. 6789
Date 11-11-46
Estimate No. _____
(Use this No. as reference on factory orders)
Date _____
Factory _____

Customer Refrigerator Manufacturing Location New York City

Article Insulation Board
Size, Etc. 1" x 36" x 36" B/P. Sketch / Spec. att'hd } 2 copies required Sample Attached
Quantity Per Order 5000 pcs. Per Annum 25 M pcs. Approx. Inq. Value Account Value
Present Selling Price None Date Established None Inquiry No. None Last Order No. None
Classification of Account:— [redacted] Equipment Mfgr. [redacted]
Is Commodity Resold No or Part of Equipment Yes
Competitor Competitor's Price Recommended Stock
Brief explanation of item: Require 1 in. thick light weight insulating material between interior and exterior walls of refrigerators. Must have high insulating qualities, non-absorptive, some structural strength, must not sag or shred out from slight vibration after installation.

If new product or new development, explain fully on back of form regarding competition, product requirements, etc. Also include details concerning patents or patent rights.

This selling price is subject to revision at any time except in case of contract customers and then the prices are subject to revision at the beginning of the next quarter.

Code 5301 Est. 17--6799

Royal Insulation (Cellular) Board

36" x 36" x 1" $---.-- per sq. ft.

Mold G-43859

Quotation based on standard size boards.

Refer to estimate No. (as filled in by factory) when entering factory orders.

Date _____ Factory _____ By _____

White - To be filled in by Factory and returned to Branch.
Pink - To be retained by Factory.
Blue - To be retained by G.S.D.
Green - To be sent to G.S.D. at time Factory copies are mailed.
Goldenrod - To be returned to G.S.D.
Buff - To be retained by Branch and forwarded to G.S.D. after inquiry is settled.

Fig. 3—Typical Sales Department inquiry requesting the development of an article for a customer.

to be done. All are present when progress on projects is reported and have a voice in any alteration of a program. Thus friction between departments, particularly when plans go wrong, is avoided since each department has equal responsibility.

RIGHT PRICE. Goods must be offered at the right price. Price, of course, is determined by cost. The aim in the Development Department is to keep the cost of goods as low as possible, consistent with quality. In this respect the work of the Department has to do with material and processing costs and not directly with labor or overhead costs. Although the development costs of each project are budgeted and accurately recorded, they become a general overhead rather than direct charges against each product. This method distributes the development costs over many products in a fixed ratio to manufacturing cost.

Production costs, overhead, quoted prices of competitors' products, supply and demand are considered in price setting. The right price is not necessarily the lowest price. Only service life will show whether low or high priced goods are more economical to the customer. The Development Department selects the kind and grades of raw materials to be bought by the Purchasing Department; it determines the proportions and amounts of these materials to be used in making the goods; and it sets up the processes. Since price and quality are closely tied together, the discussion of quality contains further information pertinent to the right price.

QUALITY OF PRODUCT. By quality is meant all the things that go to make an article satisfactory, except workmanship. Workmanship is a responsibility of the Production Department. Quality goods are believed to be the best advertisement to obtain repeat business.

The safeguarding of quality begins with the raw materials. Material specifications are written in order that the Purchasing Department will know what material is best suited for specific products. After purchased materials arrive at the plant, they are kept segregated until sampled, tested and found to comply with specifications. Checking materials against specifications is quite a chore when some 4 to 5 million pounds of raw materials comprising 300 to 400 varieties are examined each month.

DEPARTMENT ORGANIZATION. Subdivision of the Research and Development departments into groups of specialists for each phase of development work simplifies assignments and makes for more efficient over-all operation. These subdivisions are classified under:

1. Technical service groups;
2. New products group;
3. Testing laboratories;
4. Inspection laboratory;
5. Other service groups.

Each operating division of the Company operates much as though it were a separate factory. Thus, the operating divisions at Passaic might be thought of as a hose factory, a belt factory, a packing factory, a molded goods factory, a tape factory and a grinding wheel factory. Aside from supplying other divisions with partially processed materials from a central preparatory department, each division has its own specific problems and little in common with the others. The technical service groups within the Development Department comprise groups of engineers, chemists, and technicians corresponding to the various divisions. Each technical service group is headed by a technical aide, one for hose, another for belts, a third for packing and specialties, a fourth for molded goods, and so on.

The technical service groups and the new products group comprise the productive and main sections of the Development Department. The former are responsible for all technical work in connection with regular items. They are responsible for the compounds or rubber compositions, the construction of the product, the specifications of materials, the control testing of the materials and factory and sales services. They are also responsible for improving the quality of the product and for the development of new products and processes, provided the new products are directly in line with the commodities with which they work regularly. In other words, the hose group, is responsible for all technical work relating to hose. This is just as simple an organization as possible. It has the virtue of directly placed responsibility and interest.

Problems that need to be solved in a hurry are handled by the technical service groups. Often the work is somewhat under pressure because someone is being held up waiting for an answer. It may be a customer who wants a new rubber part for the machine he is building; one who has some special operation condition where a regular conveyor belt is not suitable and some change has to be made to meet the condition; possibly some customer wants to know where rubber can be used to better advantage in his equipment; or maybe the factory is having some difficulty with a process and cannot continue manufacture until it is corrected.

The new products group, as the name implies, is concerned with the development of new products and processes. Since new products often turn out to be modifications of an old product, uncertainty occasionally arises over whether a particular problem should be assigned to the new products group or to a technical service group. In practice, the new products group is given those problems where the required properties, design, processing or application are complex and where considerable time and research are expected before a conclusion is reached. Specific projects such as Cellular rubber, Multi-Flex ducts and boots and Hydron were handled by the new products group. Tests and experimental work for both groups are conducted in the testing laboratories.

An inspection laboratory is necessary because rubber goods are manufactured to meet specifications set up by the Federal and local governments, the A.S.T.M., the Underwriters' Laboratories, and large customers such as railroads and power companies. The inspection laboratory is a place where products are tested against the specifications, many times in the presence of an outside inspector. The tests usually consist of checking dimensions, construction, properties of the component parts, and, occasionally, a type of performance test.

Other service groups perform special jobs. One group checks all the vulcanizing times and temperatures. Another works on scrap or waste control, in order to hold costs down, while a third works on all sorts of compounding. Still another searches for new and better raw materials.

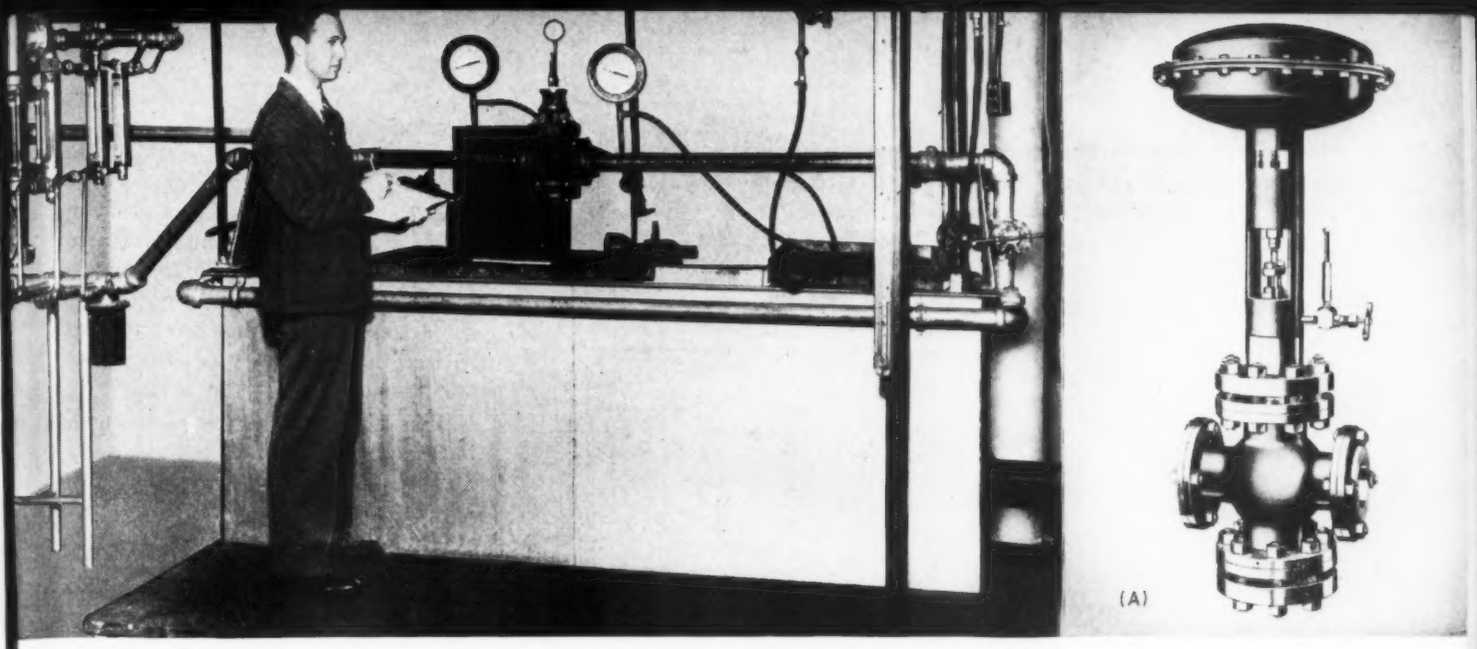


Fig. 1—Designed capacities and characteristics of control valves, of type shown at (A), are verified by experiment.

Diaphragm Control Valves Conform to Preferred Numbers

BRUCE A. IRWIN
Hammel-Dahl Company

Design details in providing a series of diaphragm control valves that have capacities that follow A.S.A. preferred numbers in addition to having a logical relationship to pipe size. Selection of control valves for control systems is discussed, including precautions to be observed when the resistance to fluid flow of other parts of the system, as well as that of the valve, must be considered.

PREFERRED numbers, as adopted by the American Standards Association, can be applied in the design of diaphragm control valves. The individual valves of such a series, like any series of motors, pumps or refrigerators designed to conform to preferred numbers, have capacities that increase by the same percent from one size to the next. Thus the size of the valve indicates an actual valve capacity. The relative capacities of two valves can be compared when the sizes are known, or the capacity of one size can be computed from that of another. Valve capacities are expressed in terms of valve flow coefficients, C_v, which have the same numerical value regardless of whether a valve is used on steam, air, gas, or water. All stated capacities are maximums measured with the valve fully open, that is with the plug at maximum lift.

A diaphragm control valve can introduce a variable resistance into any fluid flow system. While the piping, hand valves, heat exchangers, fittings, and all other equipment offer resistance to fluid flow, the control valve is the only designed means of introducing a variable resistance. One engineer calls a control valve "an engineered obstruction in a pipe line." When the flow is small, the control valve must dissipate energy in the form of a pressure drop across the valve plug. The port opening is correspondingly small, thereby throttling the flow to the desired rate. When high rates of flow are required, less energy must be dissipated, the port opening is large and the pressure drop across the valve plug is low. A diaphragm control valve could also be defined as a "Diaphragm Operated Variable Orifice."

If h is the pressure head in inches of water and C is the flow coefficient, the quantity of liquid, Q, flowing through an orifice when the pressure differential is one inch of water, is clearly shown by the familiar orifice meter formula:

$$Q = C\sqrt{h} \qquad (1)$$

The foregoing units are not suitable for valve work. Valve flow coefficient, C_v is therefore defined as the flow of water through the valve at any valve lift in gal. per min. at unit pressure drop of 1 lb. per sq. in. The valve coefficient with the plug at maximum lift (valve fully open)

Table I—Valve Sizes and Flow Coefficients C_v in Gallons of Water per Minute at Unit (1 lb. per sq. in.) Pressure Drop

Valve Size, No. or In.	Flow Coefficient, C_v	Area of Standard Pipe, Sq. In.	Valve Size, Dia. in In.	Flow Coefficient, C_v	Area of Standard Pipe, Sq. In.
No. 5	0.10	——	1	10	0.864
No. 4	0.16	——	1-1/4	16	1.495
No. 3	0.25	——	1-1/2	25	2.036
No. 2	0.40	——	2	40	3.35
No. 1	0.63	——	2-1/2	63	4.79
3/16	1.0	——	3	100	7.39
1/4	1.6	0.104	4	160	12.7
3/8	2.5	0.191	6	360	28.9
1/2	4.0	0.304	8	640	50.0
3/4	6.3	0.533	10	1,000	79.0
			12	1,440	113.0

accurately expresses the actual port area of the valve and is a number that can be used to state the relative capacity of the valve. By inserting G, the specific gravity of the liquid; and P, the pressure drop across valve in lb. per sq.in. the general and practical formula for flow through the valve in gal. per min. is:

$$\text{g.p.m.} = C_v \sqrt{P/G} \qquad (2)$$

The author's basic philosophy of control valve sizing is that a 1-in. valve should have a capacity of 10 gal. per min. of water at unit pressure drop, or a flow coefficient, C_v, of ten. All other sizes, both larger and smaller should be logically related to this basic size. As most pipe sizes 1 in. and larger are rational, the C_v for any size valve, except the 3-in. size, can be approximately obtained by squaring the size and multiplying by 10. Thus 2 squared times 10 gives a flow coefficient C_v of 40 for the 2-in. size, 4 squared times 10 gives a flow coefficient C_v of 160 for the 4-in. size, and so on.

These valve sizes and flow coefficients, as well as those for fractional sizes, are listed in Table I. Starting with the 1-in. valve, the coefficient for each succeeding fractional size increases by 60 percent through the 2½-in. size. The 3-in. size follows the 60 percent series but the preferred number of 100 has been selected rather than 90. Sizes beginning with 3/16 in. have coefficients 1/10 as large as the sizes beginning with 1 in. Valve size beginning with No. 5 (too small for pipe size comparison) have coefficients 1/100 of the series beginning with the 1-in. valve. Valve body dimensions in valve sizes 6 in. and larger alone determine the valve flow coefficient so that the 60 percent preferred number series disappear, and the coefficient C_v is determined by squaring body size times ten.

Liquid flow through all sizes from a No. 5 spline plug, or any size from 3/16 to 12 in. can be readily taken from the flow capacity chart shown as Fig. 2 as follows: Find the intersection of the pressure drop line and the specific gravity line. Draw a line parallel to the "flow in gal. per min." scale to the intersection with "gal. per min." line. The valve-size line immediately above this point of intersection gives the required size. For example, assume that a flow of water of 150 gal. per min. is wanted at a pressure drop of 25 lb. per sq. in. The 150 and the 25 coordinates for a specific gravity of one intersect between the 1½ and 2 in. sizes; hence a 2 in. valve would be selected.

The network chart can be used for any liquid provided the Reynolds number of the flow through the valve is greater than 4,000 and the liquid does not vaporize in the valve.

A similar chart for small rates of flow is given in Fig. 3 for a series of twenty small interchangeable spline plugs. These plugs, one of which is shown in Fig. 4, are used in pilot plant installations. They carry no pipe size. The No. 20 plug for example, has a maximum capacity of 0.001 gal. per min. of water at 100 lb. per sq. in. pressure drop, equivalent to 3.785 c.c. and can control a minimum flow of 0.075 c.c. of water at this pressure drop.

Steam and Gases

The basic value of the flow coefficient C_v for a given size valve is the same for liquids, gases and steam. Initially this coefficient is verified ex-

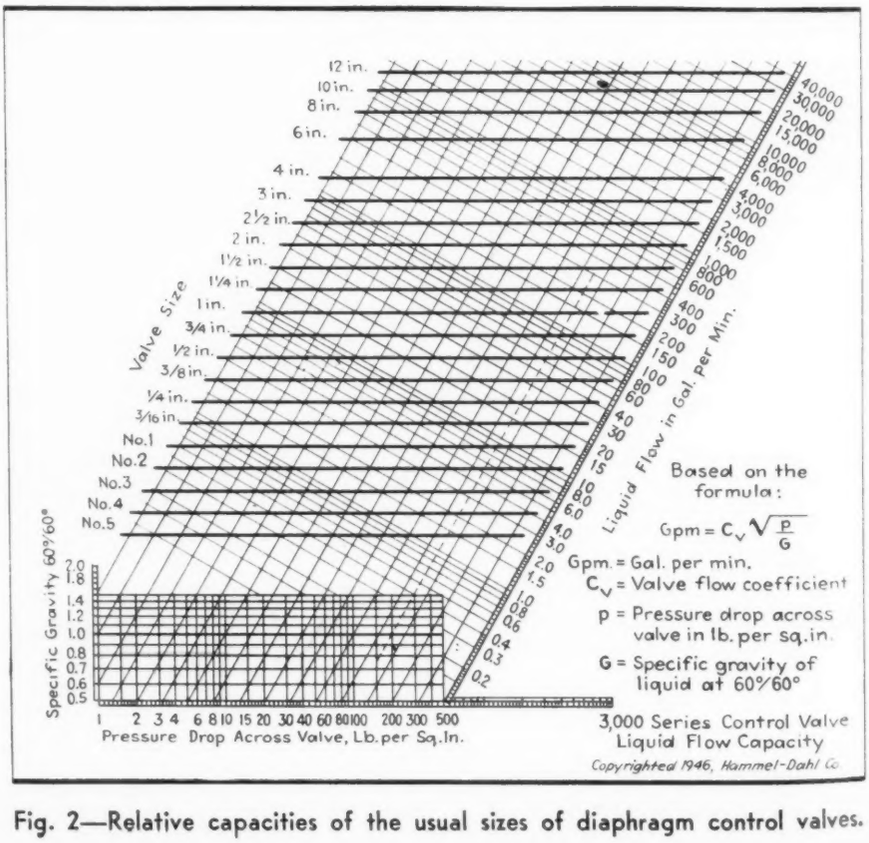


Fig. 2—Relative capacities of the usual sizes of diaphragm control valves.

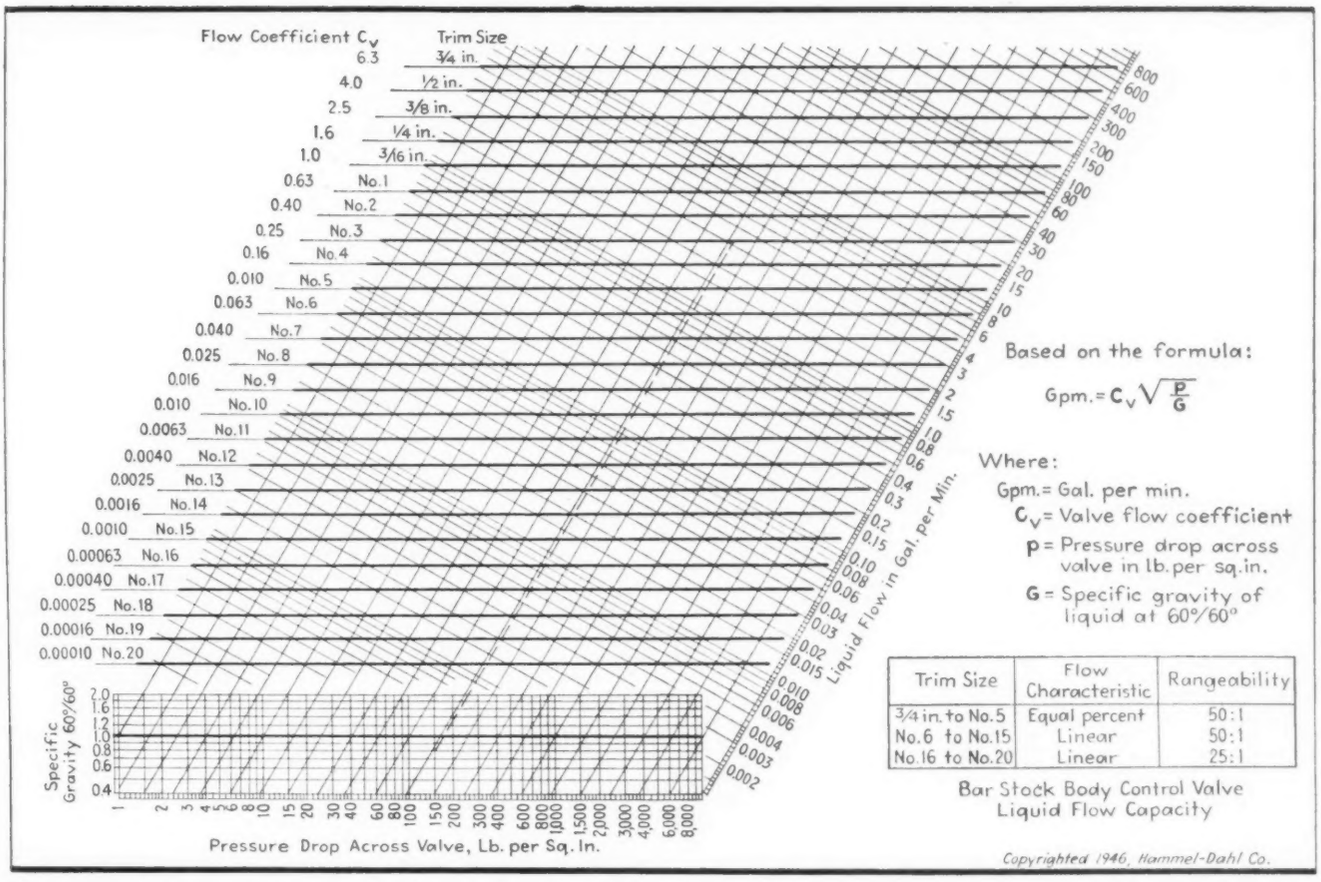


Fig. 3—Relative capacities and valve coefficients of small control valves, suitable for pilot plant control systems.

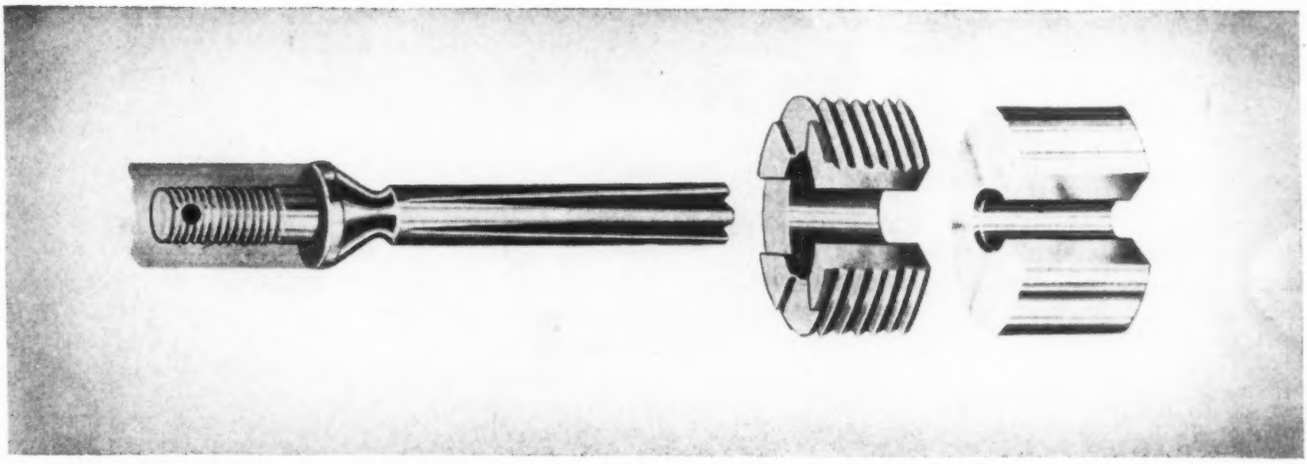


Fig. 4—Spline plug with honed seat and threaded retainer are used to produce micro flows.

perimentally, using any convenient liquid or gas. With the plug at maximum lift, that is with the valve fully open, the measurement of flow accurately gages the actual port area of the valve. Port area always fixes the flow coefficient and the capacity of the valve regardless of the medium used in checking the design. Water is used most often as the medium in verifying designs experimentally. A flow test bench, Fig. 1, is convenient for determining valve capacity, flow characteristics and performance.

The corresponding flows of steam and gases can be computed. If V is the specific volume of the inlet steam and p is pressure drop across the valve in lb. per sq. in. and not greater than ½ the inlet pressure absolute, then the pounds of steam flow per hour, W, is given by

$$W = 63\ C_v\sqrt{p/V} \qquad (3)$$

For a gas at t deg. F. inlet temperature, of specific gravity G, inlet pressure P lb. per sq. in. absolute and a pressure drop of p across the valve, which cannot exceed $P/2$, the critical pressure, the flow in cu. ft. per hr. at 60 deg. F. and 14.7 lb. per sq. in. absolute, is expressed by

$$Q = 1{,}360\ C_v\sqrt{pP/(460 + t)\ G} \qquad (4)$$

The flow in pounds per hour of a gas is given by

$$W = 104\ C_v\sqrt{pPG/(460 + t)} \qquad (5)$$

Any reduction in outlet pressure below the critical ratio $P/2$ will cause

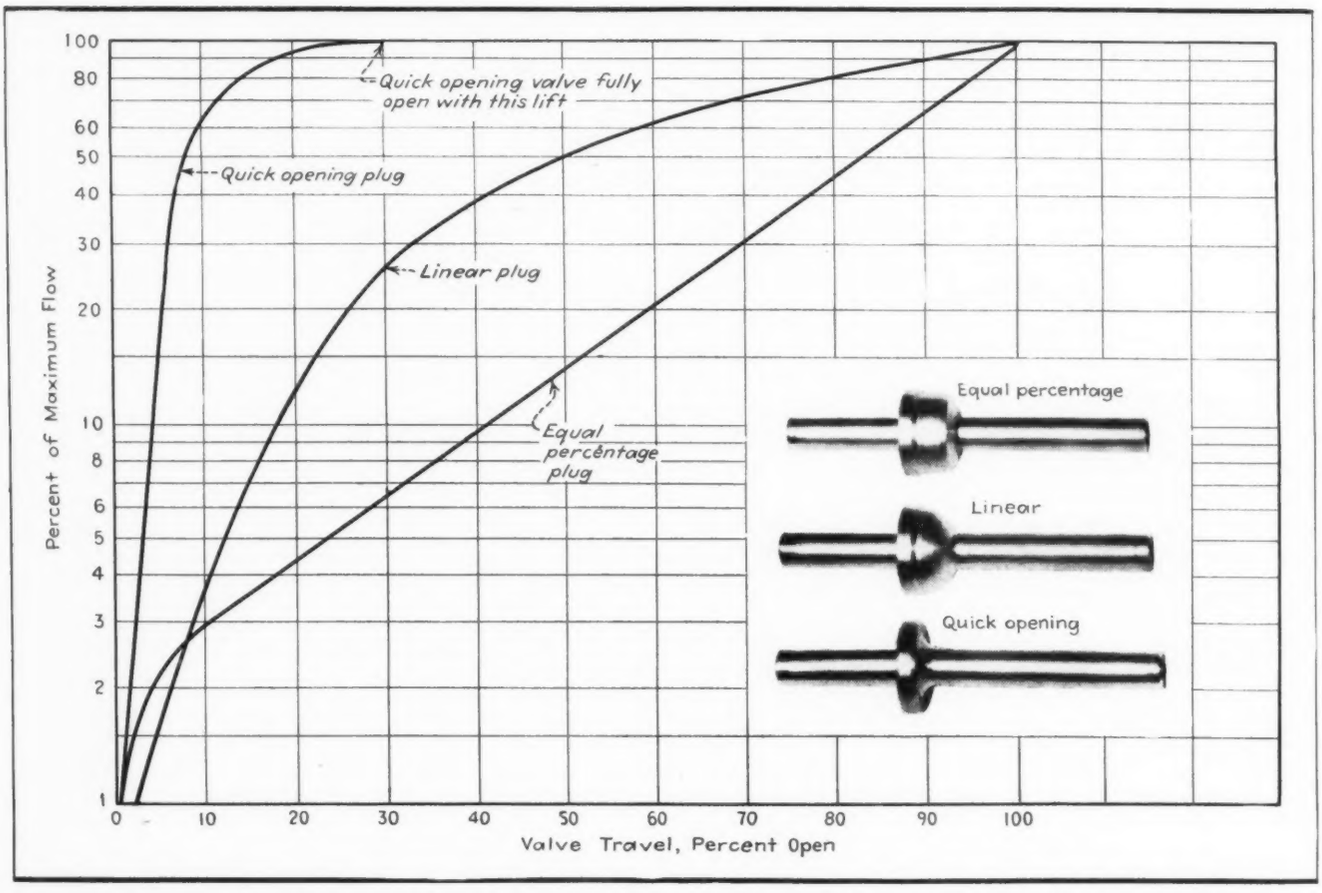


Fig. 5—Flow characteristics of three types of plugs are shown plotted on semi-logarithmic coordinates.

no increase in flow. This condition should not be overlooked in computing capacities for steam and gases.

Valve Characteristic

Control valve capacity is generally determined by the maximum flow requirements of a particular system. Once the size of the valve has been determined, control of the flow and the performance of the system depend largely upon valve characteristics. A consideration of three common shapes of plugs will illustrate how flow can vary with lift. Fig. 5 shows a quick-opening plug, a parabolic or linear plug and an equal percentage or logarithmic plug, adjacent to flow curves characteristic of each type.

It will be noted that the quick-opening plug allows 60 percent flow at 1/3 its total lift, which is equivalent to about 1/10 the lift of the other two types. This type of plug is best suited to constant pressure drops or on open-and-shut service. The parabolic or linear plug gives about 50 percent flow at 50 percent opening. In contrast, the equal percentage or logarithmic plug gives 13 to 15 percent flow at 50 percent opening.

Equal increments of lift of the equal percentage or logarithmic plug cause changes in flow that are proportional to the quantity flowing. When the flow is small, the change in flow for a given valve lift is likewise small. When the flow is large, the change in flow for the same plug movement is correspondingly large. This behavior is particularly desirable in automatic control systems where response is affected by the quantity flowing and must be proportional to it.

Several equal percentage annular plugs are shown in Fig. 6. The five single seated plugs are sizes 3/16, ¼ ⅜, ½ and ¾ in. and each has the same total lift of ½ in. They are guided at the top and bottom and can be used in either air-to-open or air-to-close action. The seat rings used with these plugs have a common outside diameter. Three seat rings in combination with the five interchangeable valve plugs, makes changes in valve capacity a simple matter. Fig. 7 shows the related maximum flow capacities obtained from this family of five plugs and also the C_v or flow coefficient of these valve plugs at any position of valve lift.

Suppose a ½ in. valve has been selected in the design of a given control system and the designer wishes to know what the lift would be under a minimum flow condition of one gal. of water per min. at 25 lb. per sq. in. pressure drop. By calculation, using Equation (2), C_v is 1/5 or 0.2. If this value of C_v is applied to the ½-in. curve in Fig. 7 a lift of 0.12 in. is obtained.

A double seated equal percentage plug is also shown in Fig. 6. Plugs of this type are used for sizes of 1 in. and larger. Fig. 8 gives the lift-flow relationships of all size valves from 1 through 12 in. This solid type plug is usually made from a drop forging, using a forming tool for machining. Because of its annular shape it can be machined in an emergency in any field shop. The shape of the plug is such that no foreign matter can adhere to its smooth contours.

Whenever the pressure drop in a

control system is concentrated at the control valve, the preferred flow characteristic is obtained by a parabolic or linear plug. On the other hand, when the control valve is in series with pumps, heat exchangers and other resistances, pressure drop across the valve is likely to be low at high rates of flow, and yet there will be a high pressure drop at the valve at low flow rates. Under such circumstances, the most desirable flow characteristic is given by an equal percentage or logarithmic plug.

Selection of the control valve therefore must be made not only on the basis of capacity, but on an analysis of the complete system. In other words, the whole flow system must be designed as a unit. Although a discussion of the design of control systems is beyond the scope of this paper, a few generalizations may be helpful toward the correct selection of proper valve types.

If pressure drop across the control valve must be selected arbitrarily, a good rule of thumb is to assign 1/3 the total pressure drop available to the control valve and 2/3 to be absorbed by remainder of the system.

A pressure drop of 15 percent across the valve is about the lowest on which successful automatic control can be based. Such low pressure drops are possible in petroleum cracking coils, through which the pressure drop is large and flow rate is steady. This low pressure drop, of course, limits the possible variation in flow.

The maximum flow that a given valve can handle should not be greater than twice the normal rate of flow. Valve size should always be computed on the basis of actual operating data, wherever possible.

The effect of variation in specific gravity in valve calculations is exactly parallel to flow measurement calculations. As it is a square root function, errors of 0.1 at a specific gravity of 1.0 for either liquid or gas would cause an error of only 5 percent, while the same error of 0.1 at a specific gravity of 0.5 would cause an error of 20 percent.

In selecting valves to handle viscous fluids, the usual practice is to make the valve one size larger than calculated. When the fluid flashes or vaporizes in the valve, determine the valve size or C_v for the liquid only, and choose a valve a size larger.

All the foregoing formulas, rules, and charts give a logical and mathematical approach to valve selection and sizing, but there is no substitute for good engineering judgment.

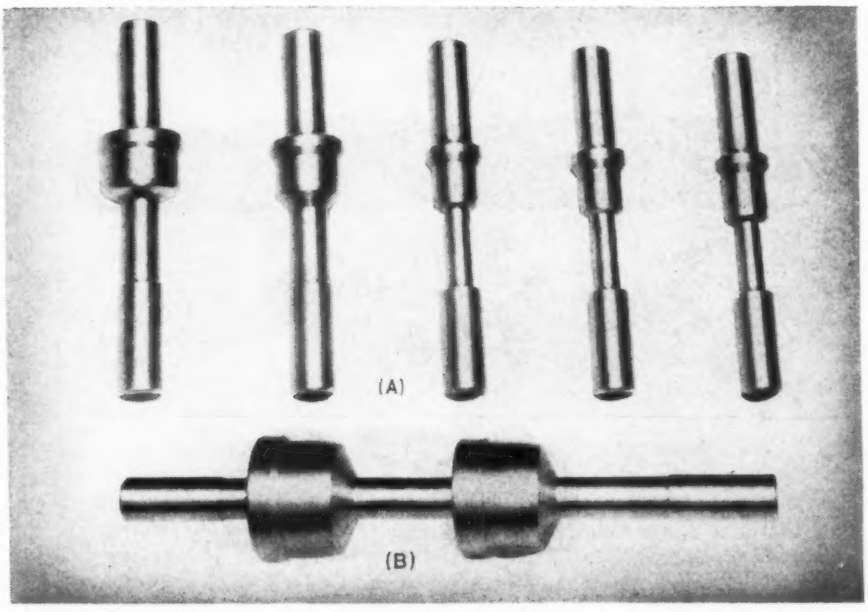


Fig. 6—(A) A family of five single-seated equal percentage plugs and (B) one double-seated equal percentage plug.

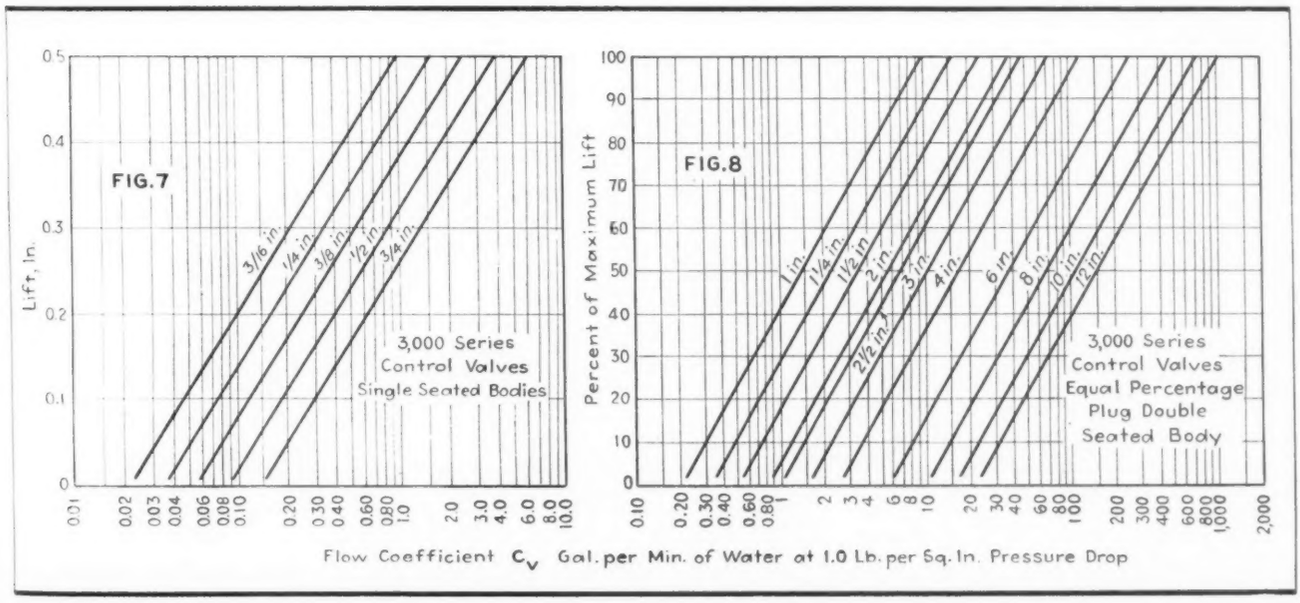
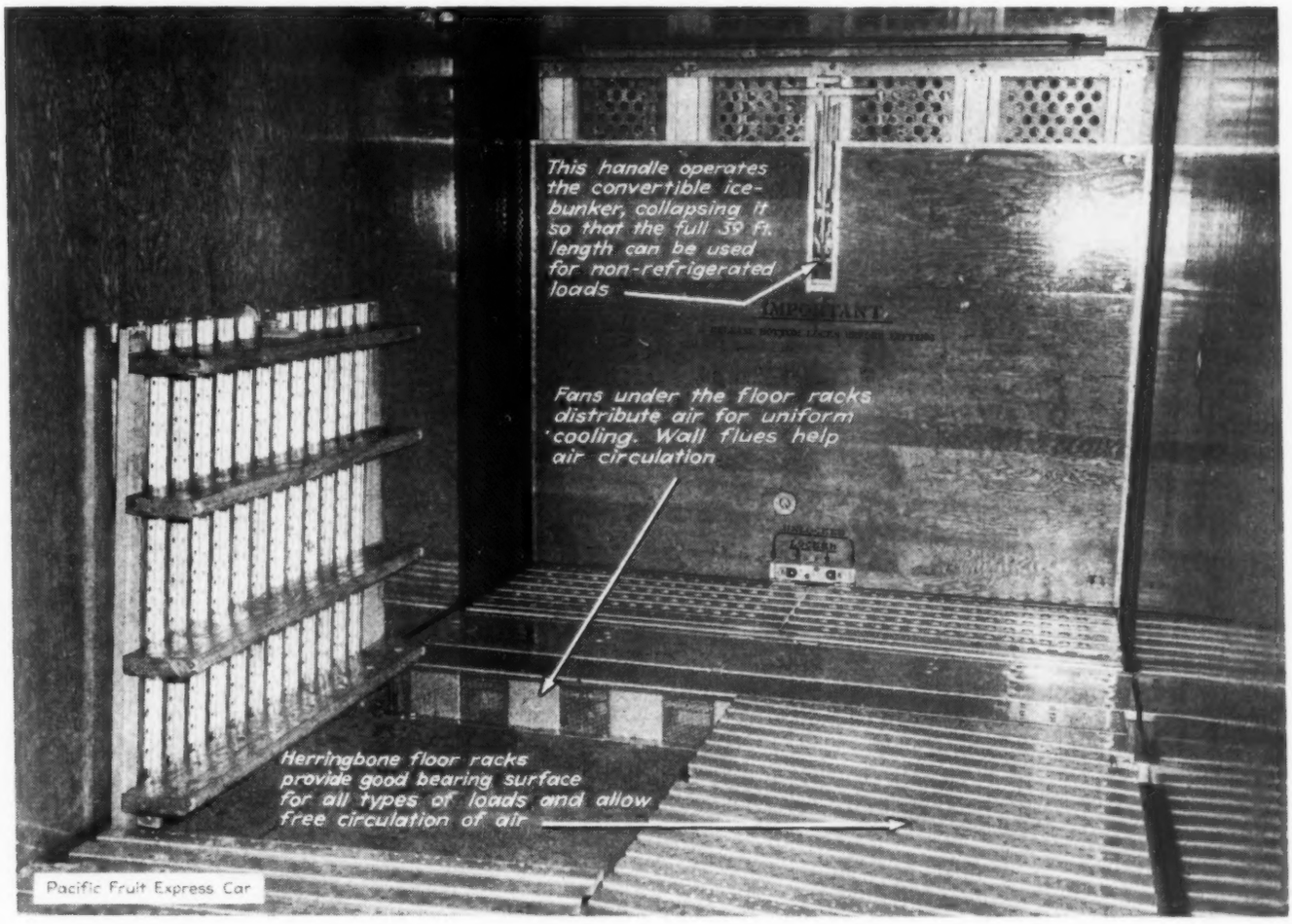


Fig. 7—Flow-lift curves for five small control valves. Fig. 8—Flow-lift curves for control valves of larger sizes.

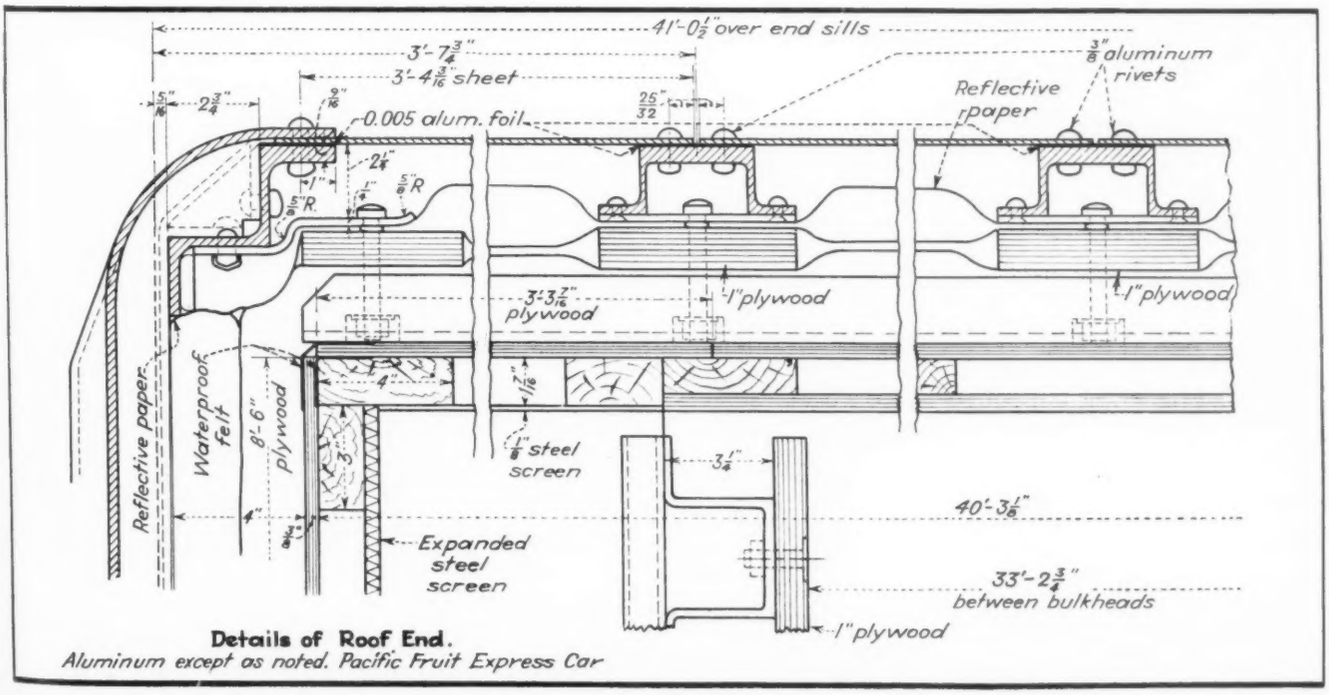
PRODUCT DESIGNS

LIGHTWEIGHT CONVERTIBLE REFRIGERATOR CARS

Aluminum alloys are steadily invading the field of heavy construction. Recent developments include these two refrigerator cars, one built by Pacific Fruit Express Company, the other by Illinois Central Railroad. Both save 5 to 7 tons, around 25 percent of the weight over prewar models, by using aluminum alloys for most body members. Under frames and other weight bearing parts are steel. The cars were built to incorporate the recommendations of the Refrigerator Car Committee of the United Fresh Fruit and Vegetable Association.


This handle operates the convertible ice-bunker, collapsing it so that the full 39 ft. length can be used for non-refrigerated loads
Fans under the floor racks distribute air for uniform cooling. Wall flues help air circulation
Herringbone floor racks provide good bearing surface for all types of loads and allow free circulation of air
Pacific Fruit Express Car

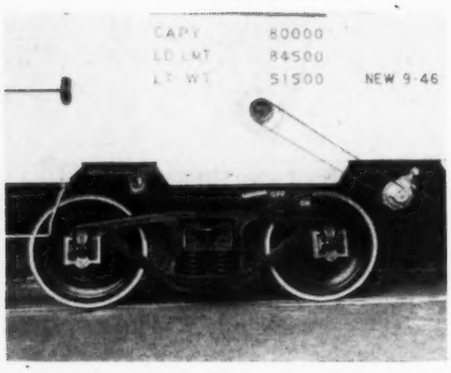
Ice bunker at end of car is collapsible so that the full **39 ft. interior** length can be used for non-refrigerated **loads. Half** stage icing **grates** are hinged for easy handling, so half as much ice can be used economically in cooler months. **(Below) Walls, ends, roof, and floor** are blanketed with lightweight insulation. Herringbone type aluminum floor racks are light and strong. Car **weight is 47,700 lb. Major** dimensions are standard.



Details of Roof End.
Aluminum except as noted. Pacific Fruit Express Car

Refrigerator Cars

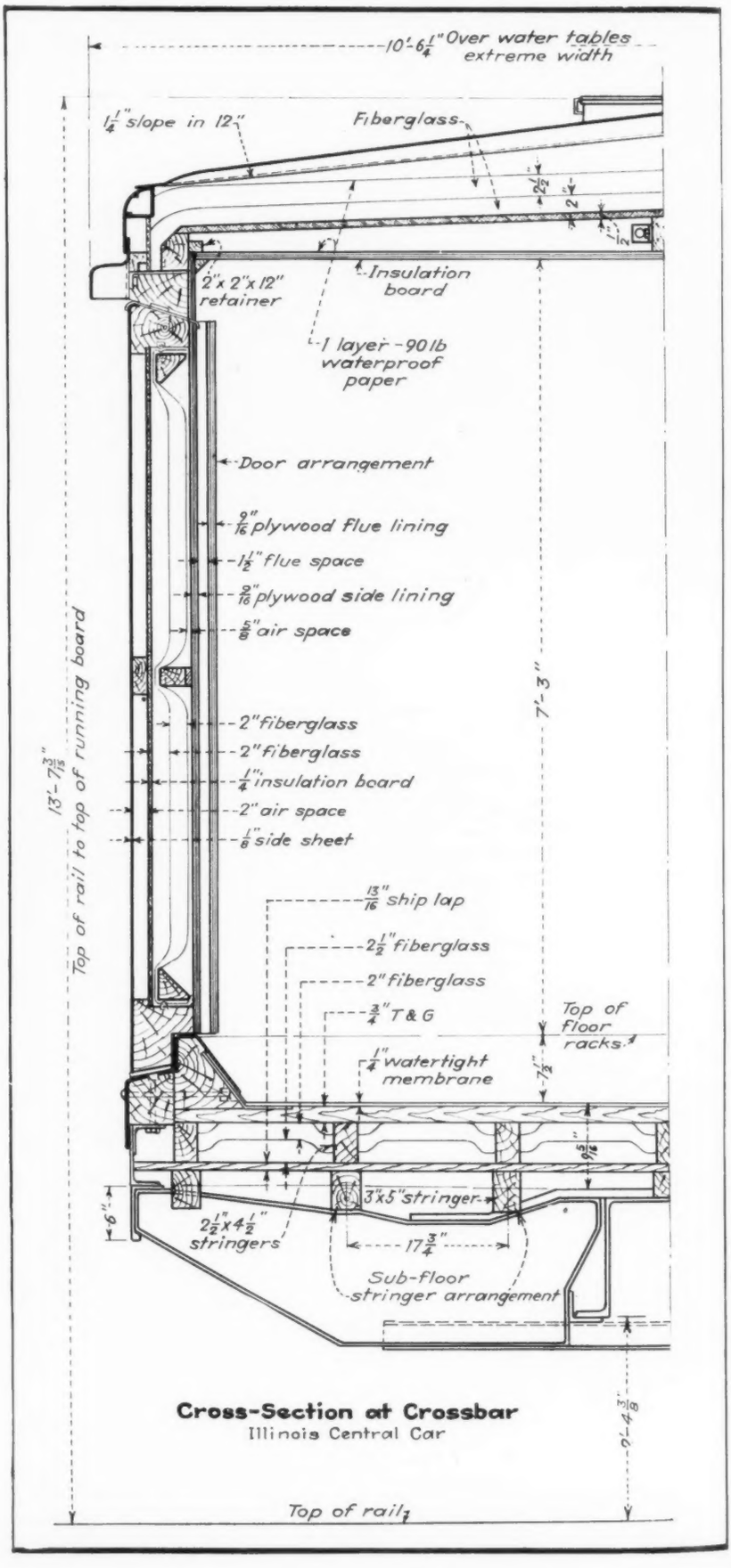
(continued)



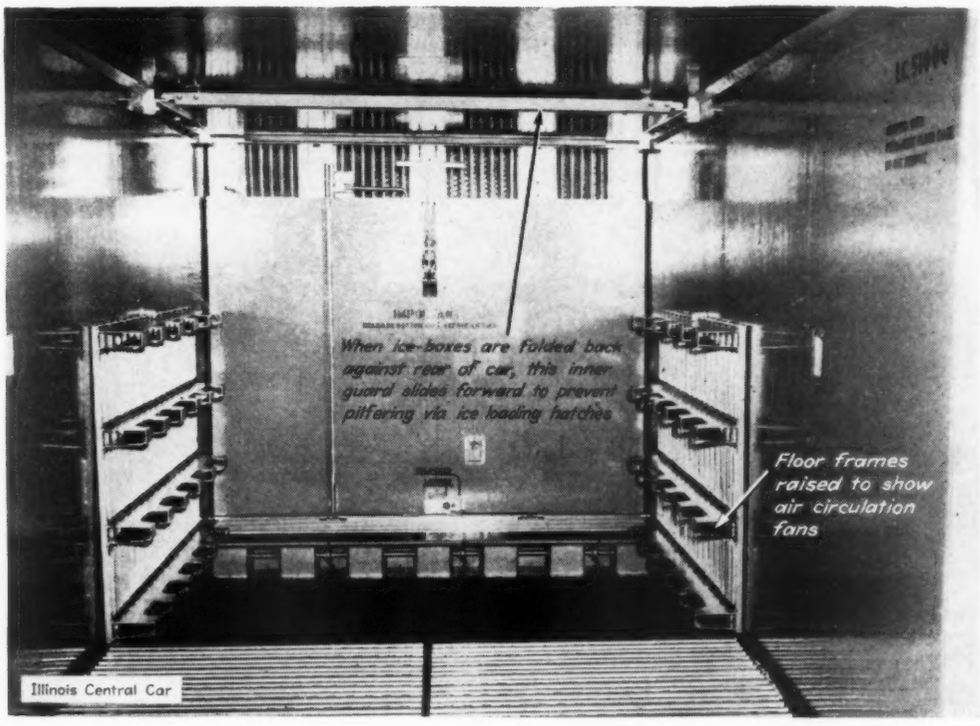
Hook-up of sheave, drive belt and stand-by motor to fan for pre-cooling of car and lading. Wall flues aid air circulation.

Tubular steel axles save 125 lb. per axle, 500 lb. per car with adequate strength.

Synthetic rubber replaces felt as a seal for the ice hatches. Aluminum replaces wood for greater cleanliness, sanitation and non-retention of food odors. Fiber glass insulation is 4 in. thick. Duryea cushion type underframe is used, in which the center sill is resiliently attached to car structure to protect body, lading, and underframe against rough handling.

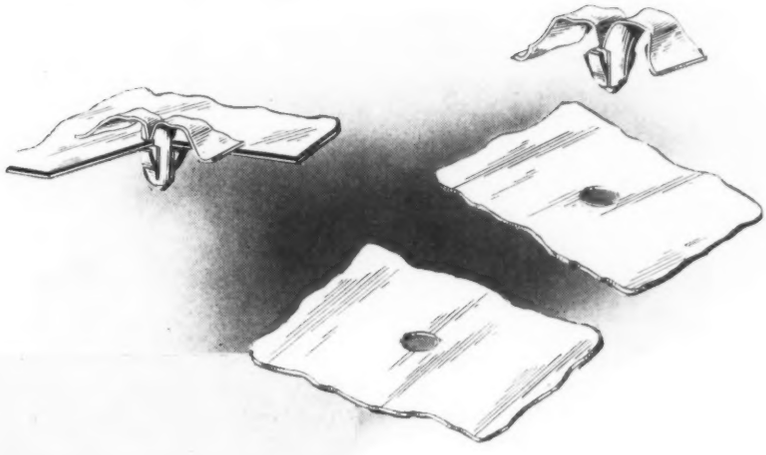


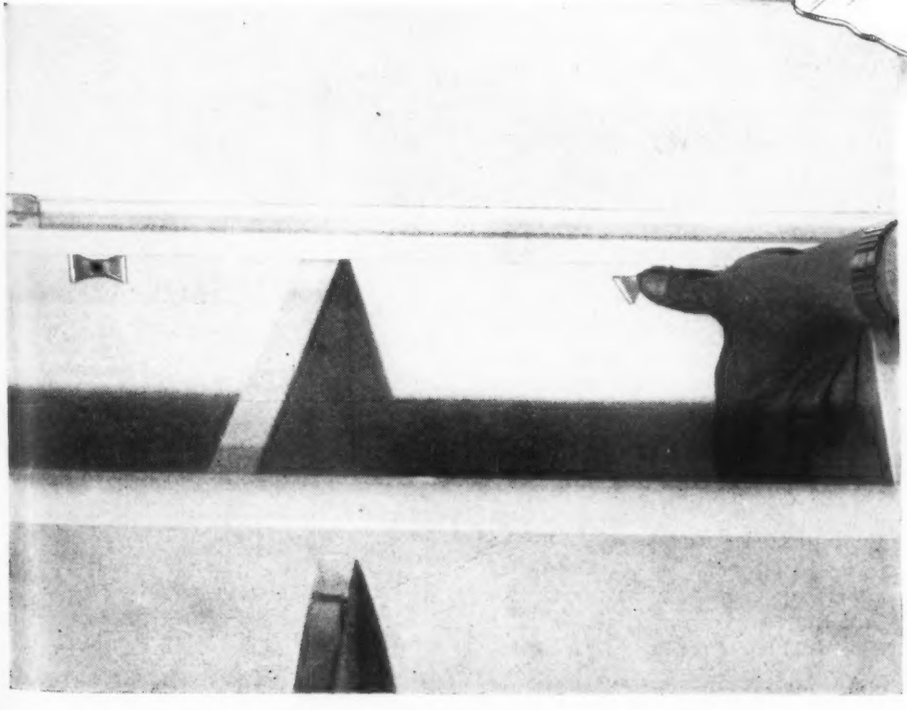
Cross-Section at Crossbar
Illinois Central Car


When ice-boxes are folded back against rear of car, this inner guard slides forward to prevent pilfering via ice loading hatches
Floor frames raised to show air circulation fans
Illinois Central Car

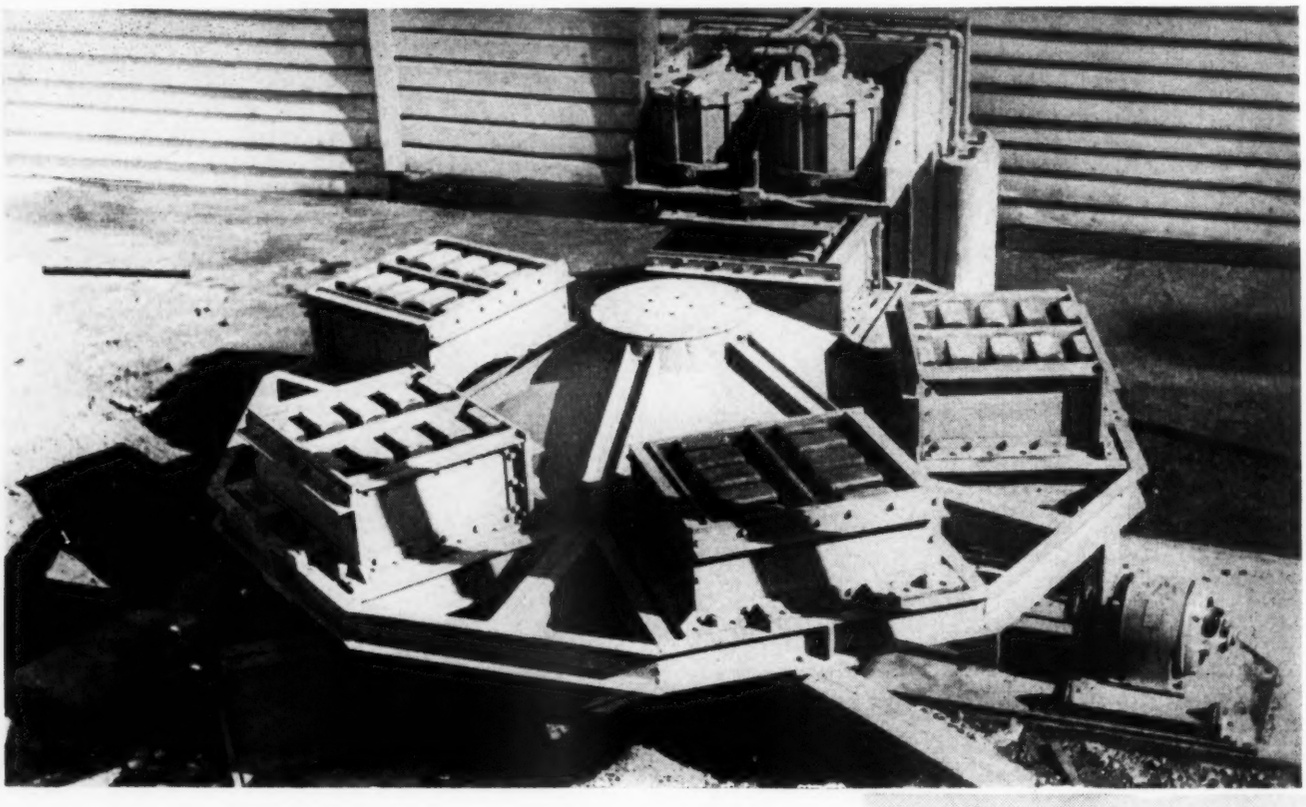
Air ducts for protective cooling of side walls, aluminum floor racks, collapsible ice bunkers, forced air circulation and electric lights for loading convenience are also features of the Illinois Central car.

One-piece Spring Steel Snap Fastener



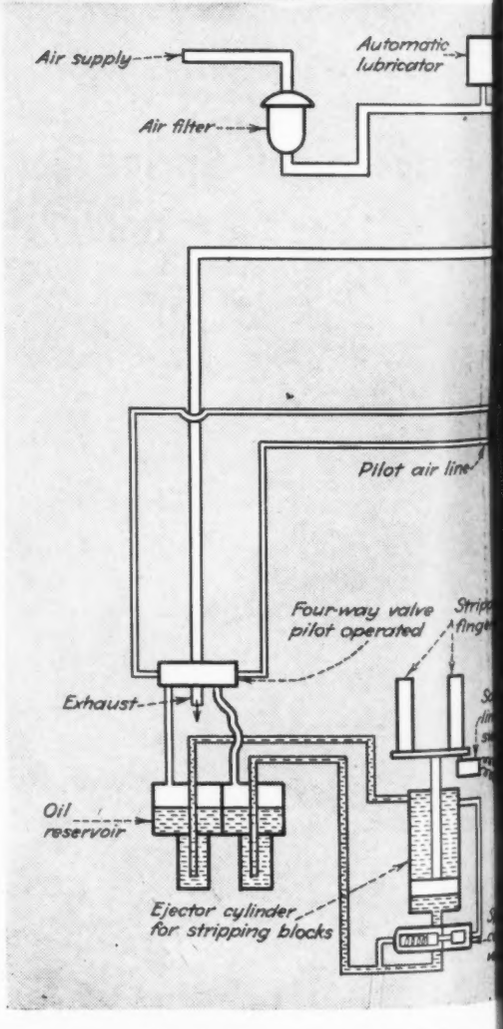


Designed to fasten sheet members $\frac{1}{64}$ to $\frac{3}{32}$ in. thick together in less than half the time required for screw or nut installation. Only requirement is that mating holes be punched or drilled where the fastener is to be mounted. When the fastener is pushed into position the prongs spring out on the far side of the assembly to hold the sheets together and provide a lock against excessive vibration. Because of its simple application the fastener is particularly useful in confined areas where screws and nuts cannot be tightened readily. By squeezing the prongs together with pliers the fasteners can be removed and then reused. The snap fastener is a product of Shakeproof Inc., Chicago.



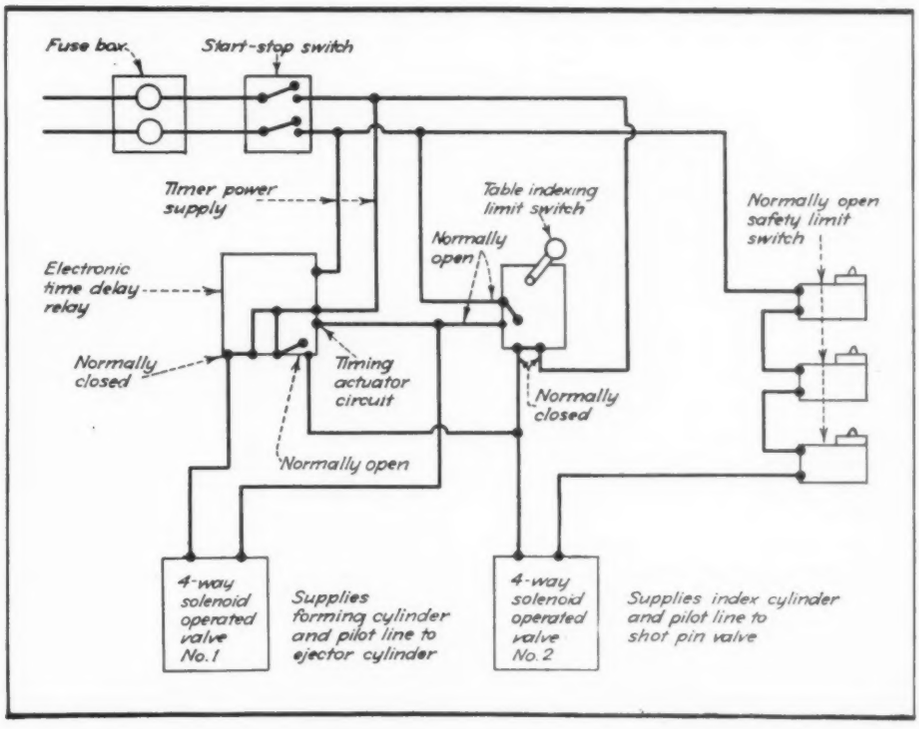
Concrete Blocks Automatically Formed

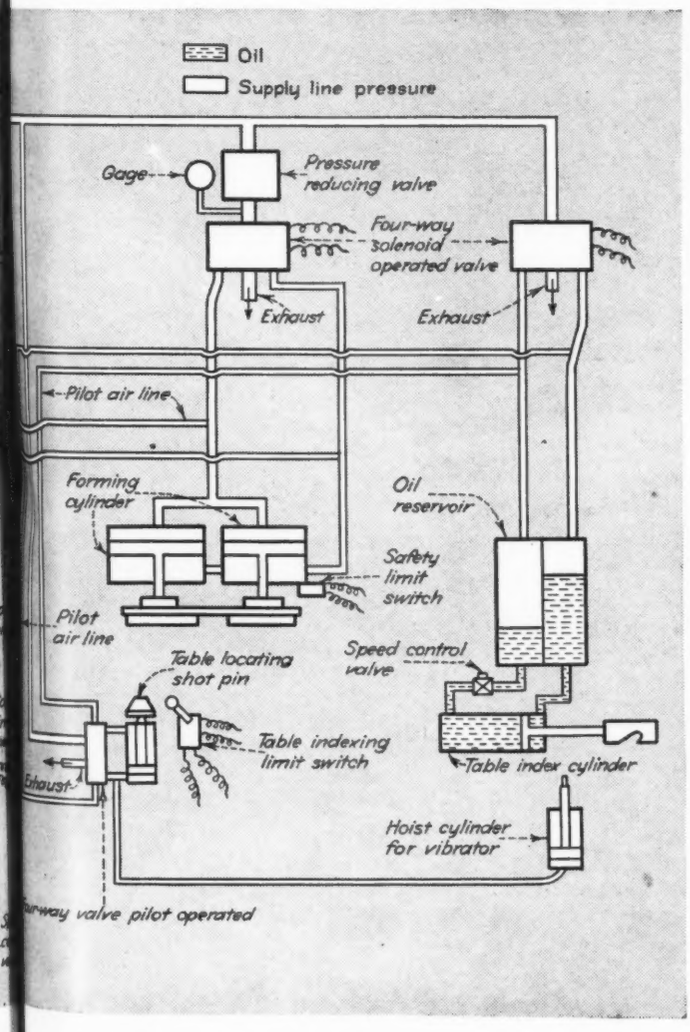
AUTOMATIC concrete block machine is air-hydraulically operated, electrically controlled and timed and produces 20 blocks per min. It consists of a rotary table mounting five mold boxes, each with two 8x8x16 in. block molds. Four operations are performed successively at the four stations. Station #1 has a hopper, charging mechanism, and vibrator. At station #2 the block is compressed and formed to size by two air cylinders. The forming pressure is adjustable from zero to 12,000 lb. per sq.in. to best suit the particular block being made and aggregate used. At station #3 blocks are stripped from the mold by a hydraulic cylinder. An off-bearer removes the blocks from the machine. The off-bearer may be manual or automatic, utilizing a conveyor to deliver the blocks to the door of the curing room. At station #4 the pallets are replaced in the mold box either automatically or manually as desired. The concrete block machine designed and manufactured by Henry & Hutchinson, Inc., Decatur, Ga., requires no attention from an operator.

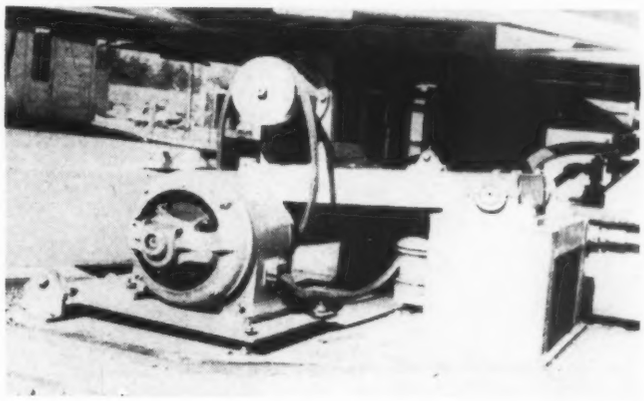


Blocks of varying densities can be produced by controlling the concrete mixture, length of vibration time and pressure exerted by the forming cylinders at station #2. The machine is constructed of welded steel. Wear is kept down by automatic lubrication and protection of the few operating parts. No rotating cams, gears, or other mechanical mechanisms are used. Mold boxes are lined with replacable ½ inch steel armor plate.

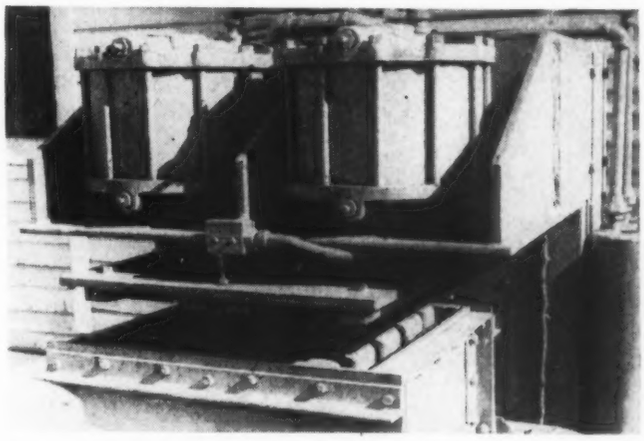
Table indexing switch and the time delay relay are shown in rest position. When the table reaches a station, a cam operates the table limit switch, stopping table motion, initiating the operation of the shot pin and ejector cylinders, and returning the table indexing cylinder. The #2 valve turns the table upon energization, and returns the draw rod upon breaking the circuit. The #1 valve applies power for forming and stripping the blocks upon energization, and returns the cylinders to rest on de-energizing the solenoid.


Fuse box
Start-stop switch
Timer power supply
Table indexing limit switch
Normally open
Normally open safety limit switch
Electronic time delay relay
Normally closed
Timing actuator circuit
Normally closed
Normally open
4-way solenoid operated valve No. 1
Supplies forming cylinder and pilot line to ejector cylinder
4-way solenoid operated valve No. 2
Supplies index cylinder and pilot line to shot pin valve





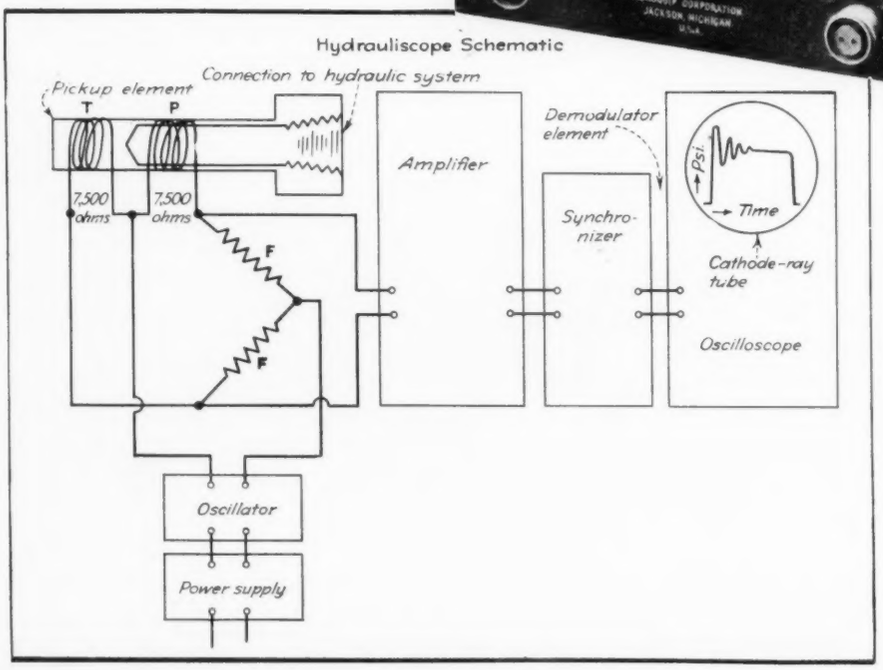
Efficient vibration, in intensity and time in combination with controllable pressure, enables the machine to produce blocks of varying characteristics.



Two air cylinders at the forming station are supplied with air at 150 lb. per sq. in. by a 140 cu. ft. compressor.

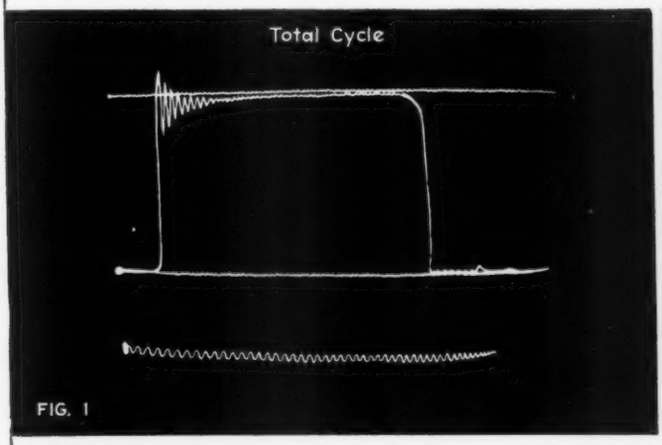
Strain Gage and Oscilloscope Combined in Hydraulic Analyzer

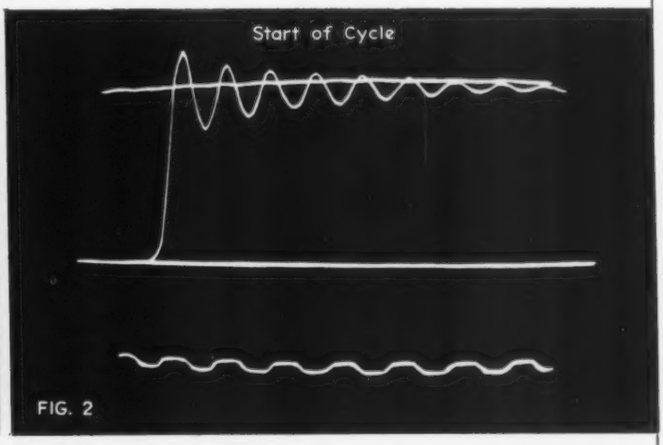
PRESSURE GAGES have too much inherent inertia to indicate correctly the peak pressures and rapid surges in high pressure hydraulic systems. Standard oscilloscopes, strain gages, and amplifiers are expensive and require highly trained operators to obtain correct results. The Hydrauliscope is an high speed electronic analyzer combining these elements in a portable instrument that can be operated by any engineer to investigate hydraulic pressure phenomena. It consists of a pressure pickup that transforms pressure changes into electrical impulses and a cathode ray tube which reflects these impulses in the form of a moving dot, which traces a pressure-time curve that can be seen. The instrument is built by Aeroquip Corporation, Jackson, Mich.



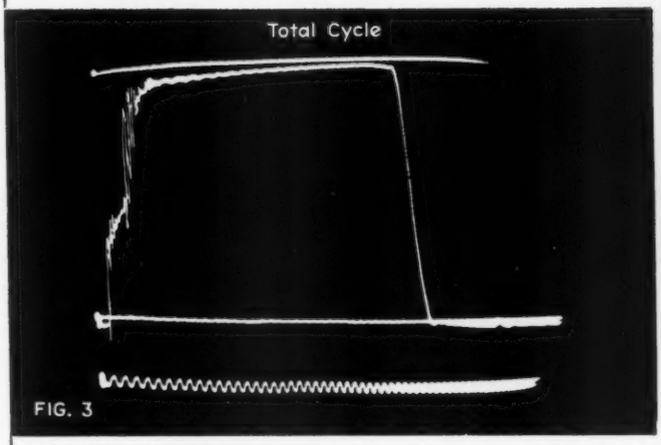
The wheatstone bridge is the basis of the instrument. One leg, **P**, is a wire strain gauge wound around a hollow, pressure-sensitive tube, another leg is wound on the solid end of the pickup element for temperature compensation purposes. Resistance changes in the active leg during expansion under pressure cause voltage differentials across the bridge. These minute voltages are amplified and shown with an oscilloscope. Power supply, d. c. amplifier, cathode ray tube, horizontal sweep control, and miscellaneous controls are built in.

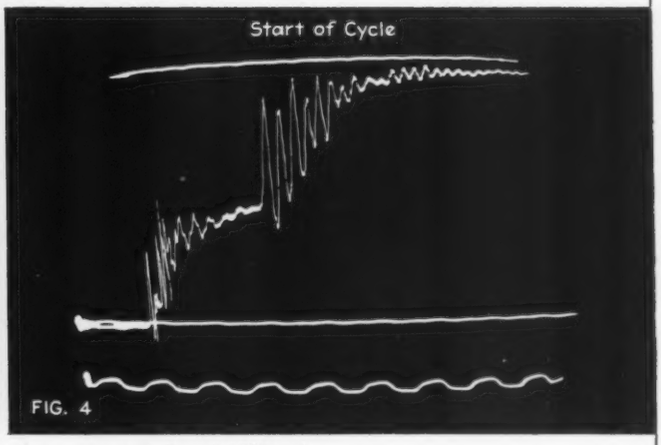
Machine A





Machine B

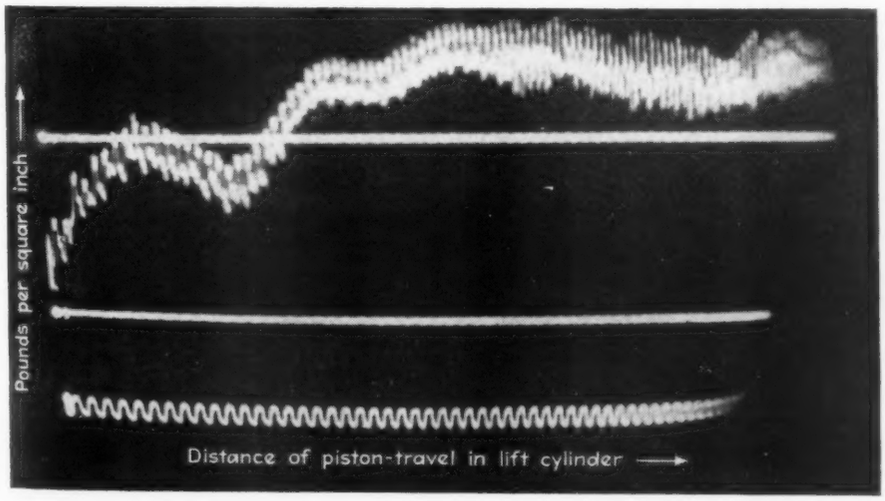




On each graph: Time wave is 1/60 sec. peak to peak, reference lines represent 0 and 1,500 psi

Pressure–Time Curve Comparisons of Two Hydraulic Impulse Testing Machines

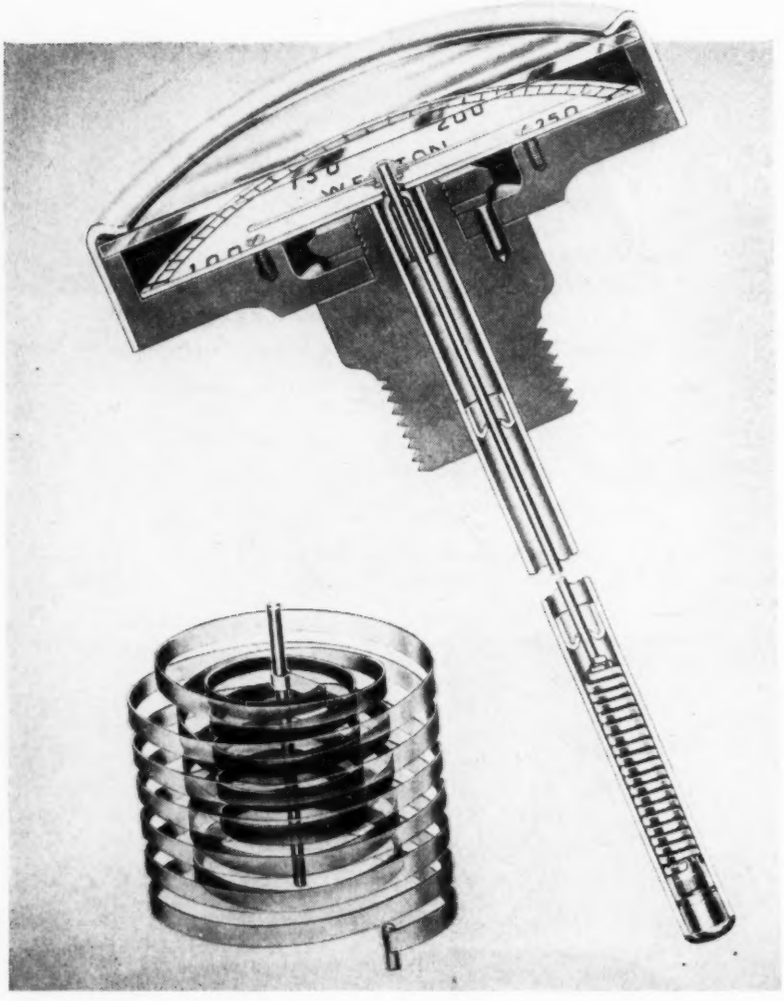
An example of Hydrauliscope use is shown by pressure graphs of an impulse cycle taken from two different types of hydraulic impulse testing machines. Figs. 1 and 3 show the complete impulse cycle of both machines. Figs. 2 and 4 show the initial portion of the pressure cycles, in which the speed of the time trace has been increased to show details of the rate of pressure rise. Analysis so made proves that the cycle of the testing machine as shown in Fig. 1 and 2 not only produced pressure peaks in excess of 1,500 lb. per. sq. in., but also subjected the specimen to maximum pressure in a fraction of the time required by the other machine.



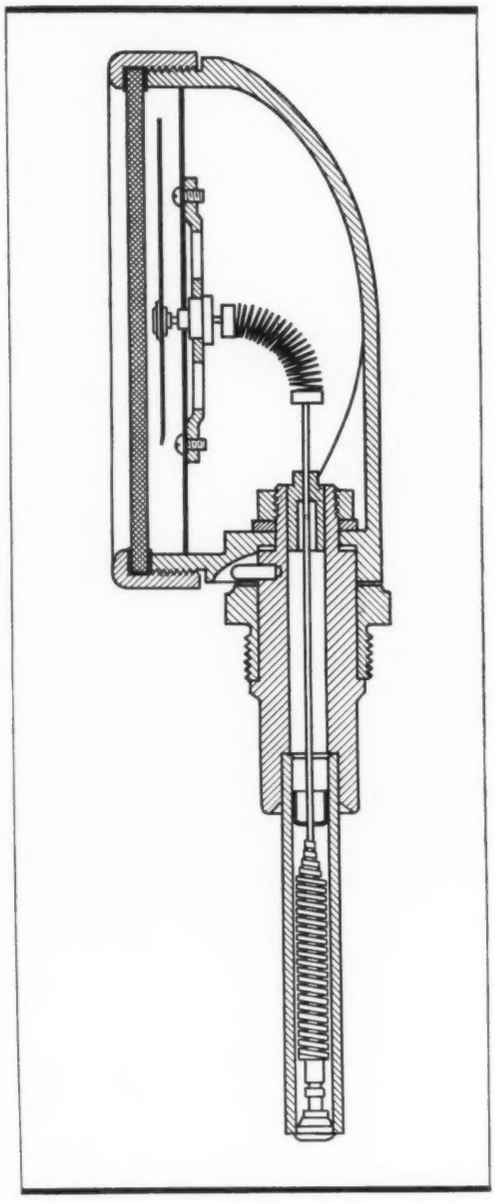
Curves of pressure against mechanical motion are possible with a recent accessory development. The photograph records the history of the lift cylinder pressure resulting from picking up a full load with the empty forks of a lift truck at full lift speed. Expected high shock surges did not materialize, probably because of the tendency to raise the truck from its rear axle as the load was assumed.

Nickel Alloys Form Multihelix Thermometer Element

ALL-METAL THERMOMETERS have been delayed for lack of a suitable bimetallic thermal element. Hard rubber, even wood, riveted, screwed or cemented to brass or iron were tried without success. A nickel alloy with high, constant rate of expansion and contraction, not subject to effects of humidity and taking no appreciable set from constant cycling, provides one material. Invar, a nickel alloy with practically no expansion at normal atmospheric temperatures, furnishes the other. These two alloys, welded together and rolled to proper thickness will bend sufficiently when heated and have usable sensitivity as a thermometer. The All Metal Thermometer is a development of the Weston Electrical Instrument Corporation, Newark, N. J.



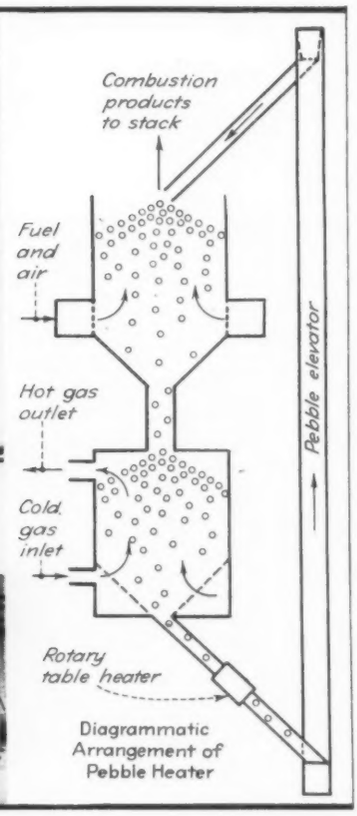
The multi-helix element has two or more continuous coils wound one within the other. End thrust is reduced since this effect in the outer coil is cancelled by the inner coil. The pitch is in opposite directions so that tendency for the pointer to be shifted laterally and axially is counterbalanced.



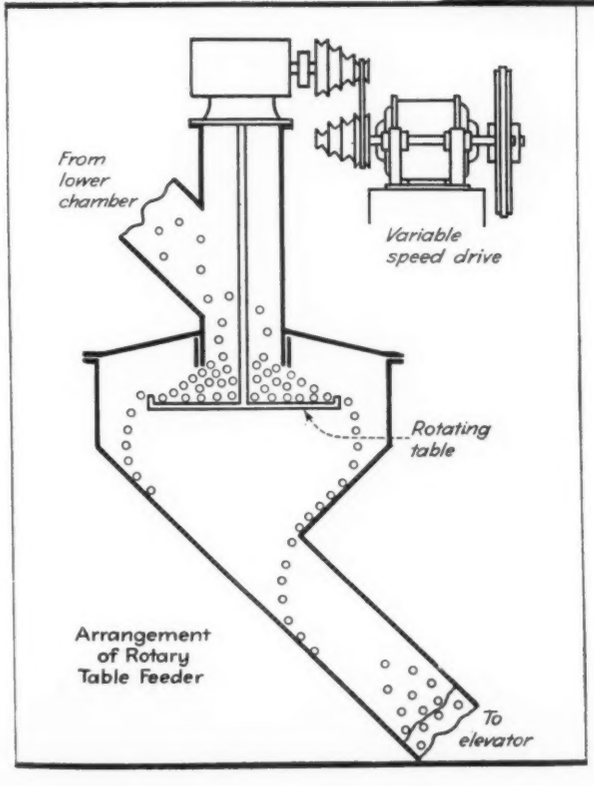
Temperature element shapes raises several problems. For sufficient pointer deflection, a strip of bimetal 15 to 20 in. long is needed. When wound, this strip must be self supporting with minimum center sag, compact in size and convenient in shape so as to fit a small tube. Helices and spirals both have disadvantages. A spiral coil, as it rotates, tends to shift the pointer out of position as the coil changes shape. This varying side thrust causes pressure against the pointer bearing, with resulting errors. Spiral shape also gives a relatively large diameter coil requiring a large stem. Helix coils tend to sag in the center, which can cause friction. They also thrust the pointer away from the scale plate as temperature increases. Multix-helix shape overcomes these drawbacks.

Pebble Heat Exchanger Performs Uniform High Temperature Gas Heating

GASES have been traditionally heated by three methods: (1) the flow of gas over or through metallic pipes while combustion products flow on the other side of the metal; (2) the same technique, substituting highly conductive refractory material, such as silicon carbide or aluminum oxide, for metallic parts; (3) by the regenerative method, where alternate cycles of combustion gases and gases to be heated are passed through a stationary refractory mass. While highest temperatures can be obtained by this latter method, outlet temperatures fluctuate and the construction is bulky. The Babcock & Wilcox Company, New York, have devised a counterflow heat-transfer apparatus, the Pebble Heat Exchanger, that delivers gases at uniform temperature, is compact, has a high thermal efficiency, and heats gases above the temperature possible with metallic heaters. The furnace comprises two cylindrical chambers connected by a narrow throat and filled with refractory pebbles.



Diagrammatic Arrangement of Pebble Heater



Arrangement of Rotary Table Feeder

A mechanical feeder below the lower chamber controls the rate at which pellets flow down through the system. Fuel and combustion air are introduced into upper chamber and the combustion products flow up through the downward moving pellets, heating them. Heated pebbles pass through throat section to lower chamber. Cold gas is introduced at the bottom of the lower chamber and, after passing through a screen to insure uniform distribution, travels upward through downward moving heated pellet bed. Heated gas leaves at top of lower chamber. Reduced throat section and balanced pressures in the upper and lower chambers prevent flow of gases between them.

Relative areas per unit volume show why the Pebble Heat Exchanger can be made much more compact than other types:

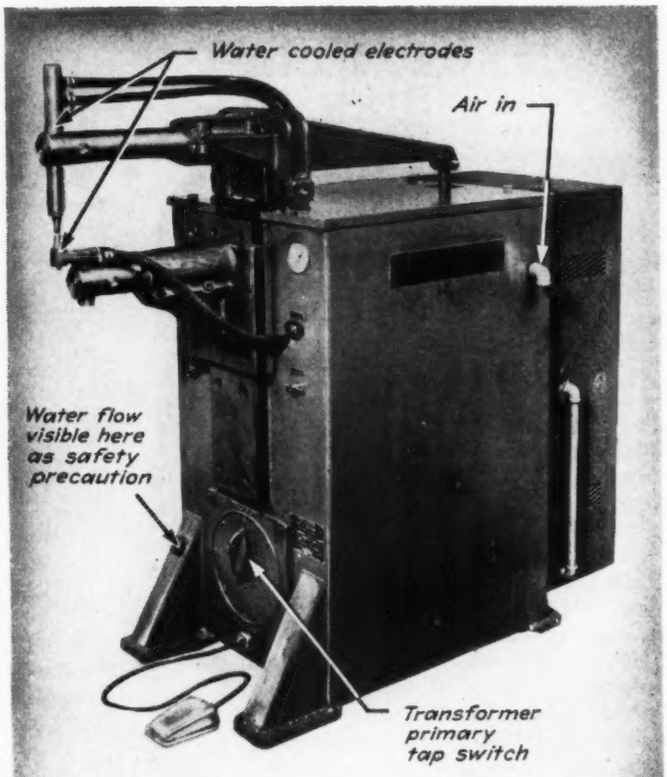
Heat-Transfer Surface per Cubic Foot of Volume

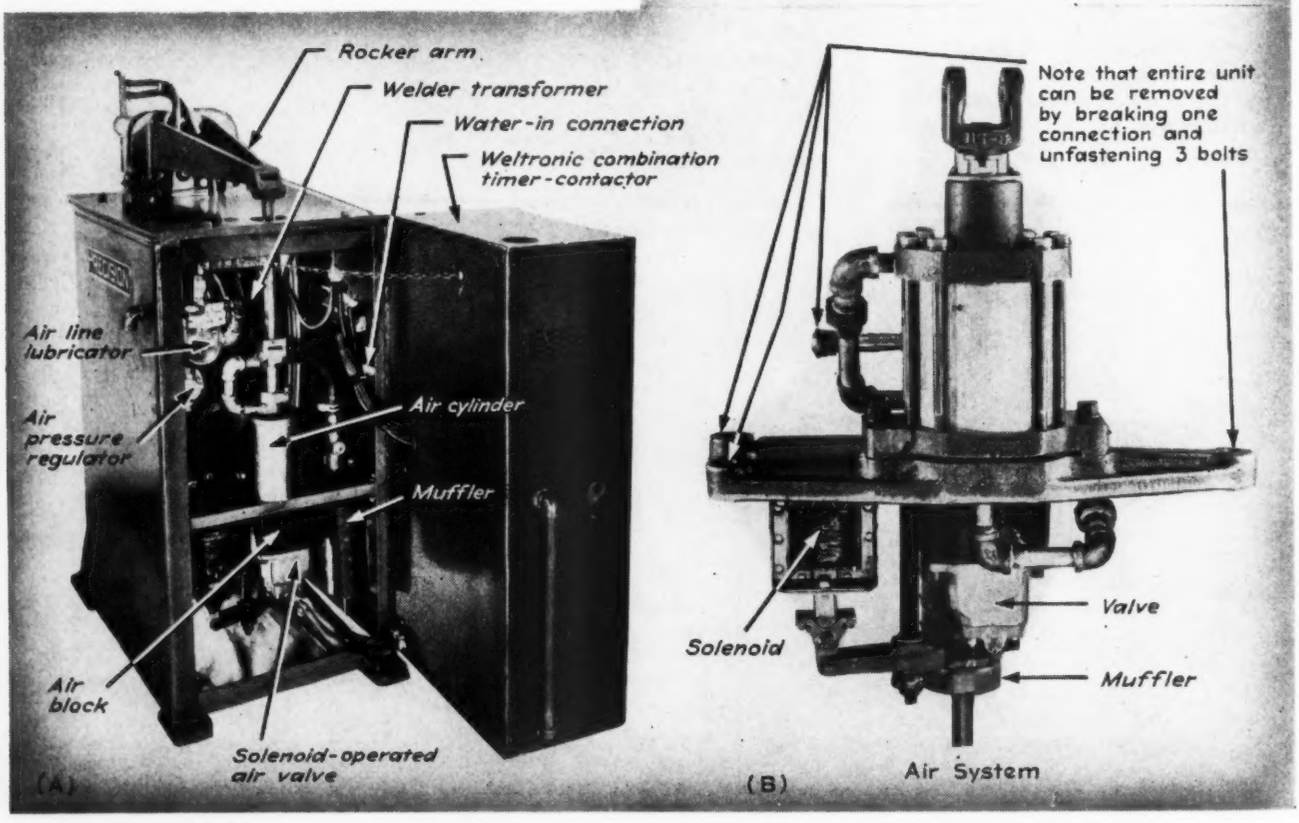
	Sq. ft.
$\frac{5}{8}$-in. pebbles	135.5
½-in. pebbles	86.5
2½-in. O. D. Steel tubes (3¼ x 3¼ in. on centers)	9.0
Regenerator checker brick	3.0–8.0

Average time per cycle is 30 to 50 minutes. The pebbles must not soften and cling together so that they "bridge" and stop the moving bed. They must withstand abrasion, repeated heating and cooling, and impact. Three types have been used successfully: kaolin, mullite, and 85 per cent Al_2O_3 composition.

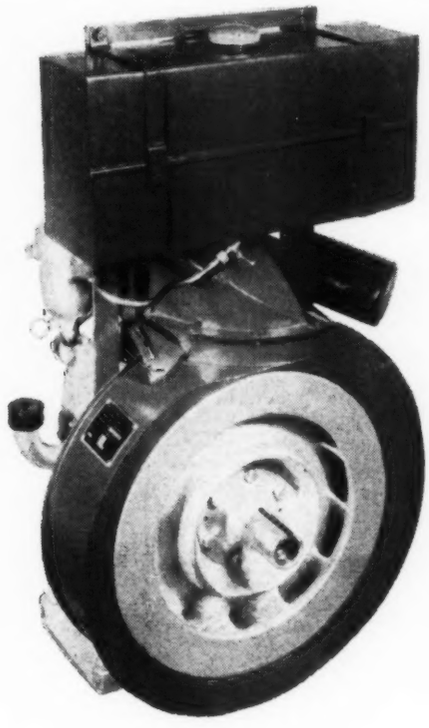
Spot Welder Designed For Production Line Use

NARROW MACHINE width with both sides clear of controls facilitates production line installation of this spot welder. It can be set up by making one electrical, one air and two water connections. All water, air and heat adjustments and gages are mounted on the machine face for operator convenience. Timer and contactor are mounted as a unit on a hinged panel at the rear. Two wrenches are sufficient to make all adjustments. Freeze plugs cover the fulcrum pin ends of the operating arm to prevent excess grease from dripping onto the transformer. Spot Welder is built by the Precision Welder & Machine Company, Cincinnati, Ohio.





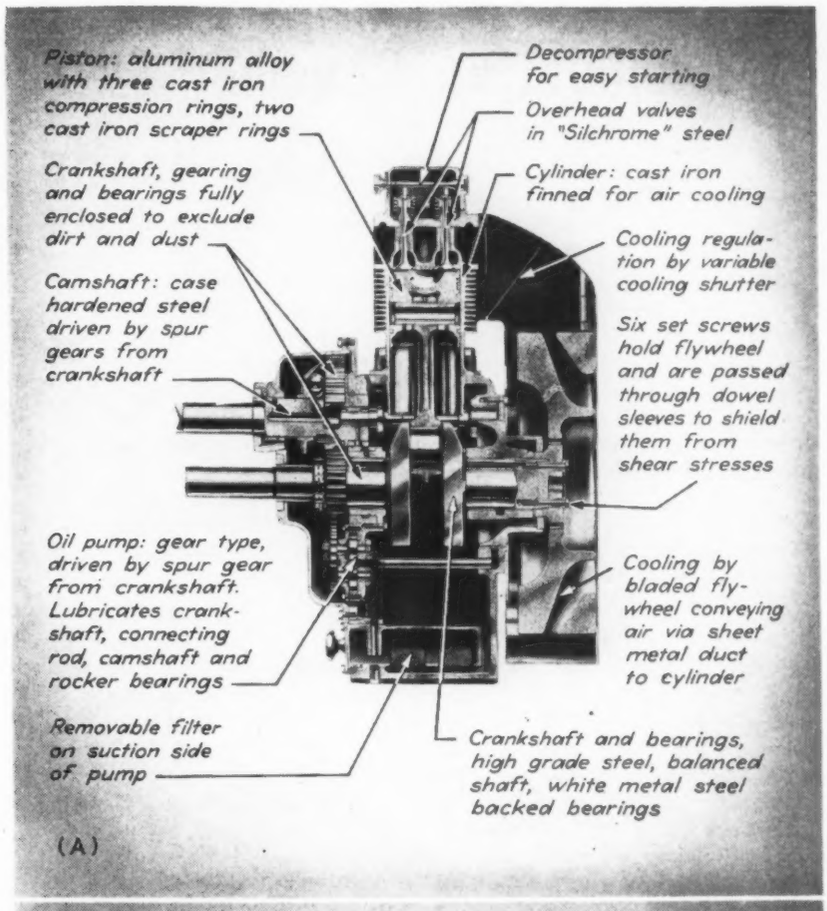
(A) Separate water circuits with individual flow control valves cool the electrodes and the welding transformer. Solid water tube connections join the top secondary connection to remove the possibility of water leakage over the welding transformer. Fifty pounds exerted by the operator produces up to 400 lb. per sq. in. welding pressure .(B) Rocker arm is air operated. An air terminal block makes unit construction possible and reduces the amount of piping. The air cylinder valve is solenoid operated and the air cylinder is equipped with a muffler for quiet operation.

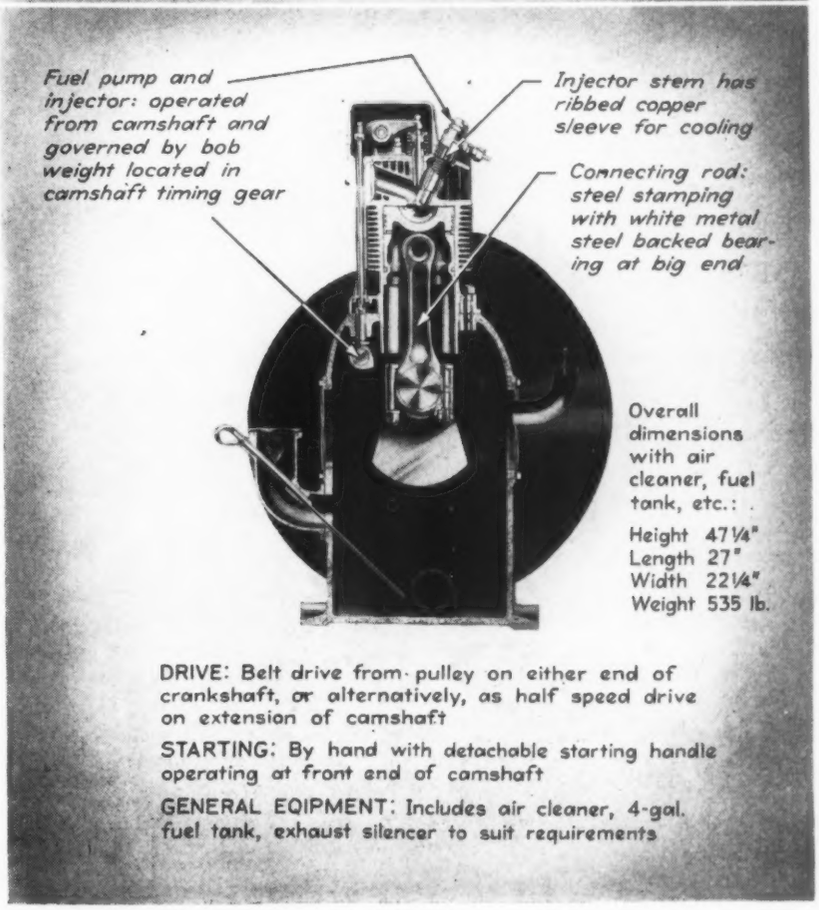


Adjustable Air Cooling For Diesel Engine

AIR COOLED ENGINES are apt to have a wider range of operating temperatures than water cooled designs. In diesel engines, one temperature extreme may cause nozzle plunger sticking and the other reduce combustion efficiency. This 6 hp., 4-stroke, direct injection single cylinder unit, built by Armstrong-Siddley Motors, Coventry, England, has two corrective features. The injector barrel is covered by a ribbed copper sleeve for high heat dispersion and the cooling air delivery can be regulated.

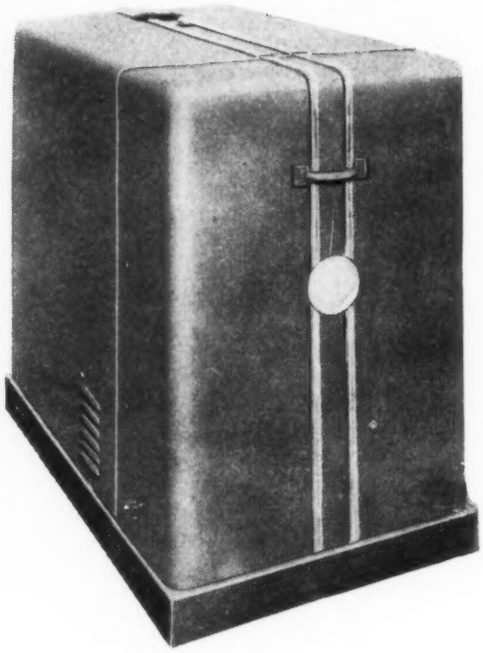
(A) Stroke and bore are 4½ in. Rating is 6 bhp. at 1,000 r.p.m. Engine is started cold using hand crank and decompressor. Compression ratio is 15 to 1. Notice hemispherical cavity in piston head. (B) The flywheel casting is vaned to form a centrifugal fan. The fan delivers air through sheet metal cowls to the cylinder subject to the air flow permitted by the position of the adjustable flap in the cowling.


Piston: aluminum alloy with three cast iron compression rings, two cast iron scraper rings
Crankshaft, gearing and bearings fully enclosed to exclude dirt and dust
Camshaft: case hardened steel driven by spur gears from crankshaft
Oil pump: gear type, driven by spur gear from crankshaft. Lubricates crankshaft, connecting rod, camshaft and rocker bearings
Removable filter on suction side of pump
Decompressor for easy starting
Overhead valves in "Silchrome" steel
Cylinder: cast iron finned for air cooling
Cooling regulation by variable cooling shutter
Six set screws hold flywheel and are passed through dowel sleeves to shield them from shear stresses
Cooling by bladed flywheel conveying air via sheet metal duct to cylinder
Crankshaft and bearings, high grade steel, balanced shaft, white metal steel backed bearings
(A)

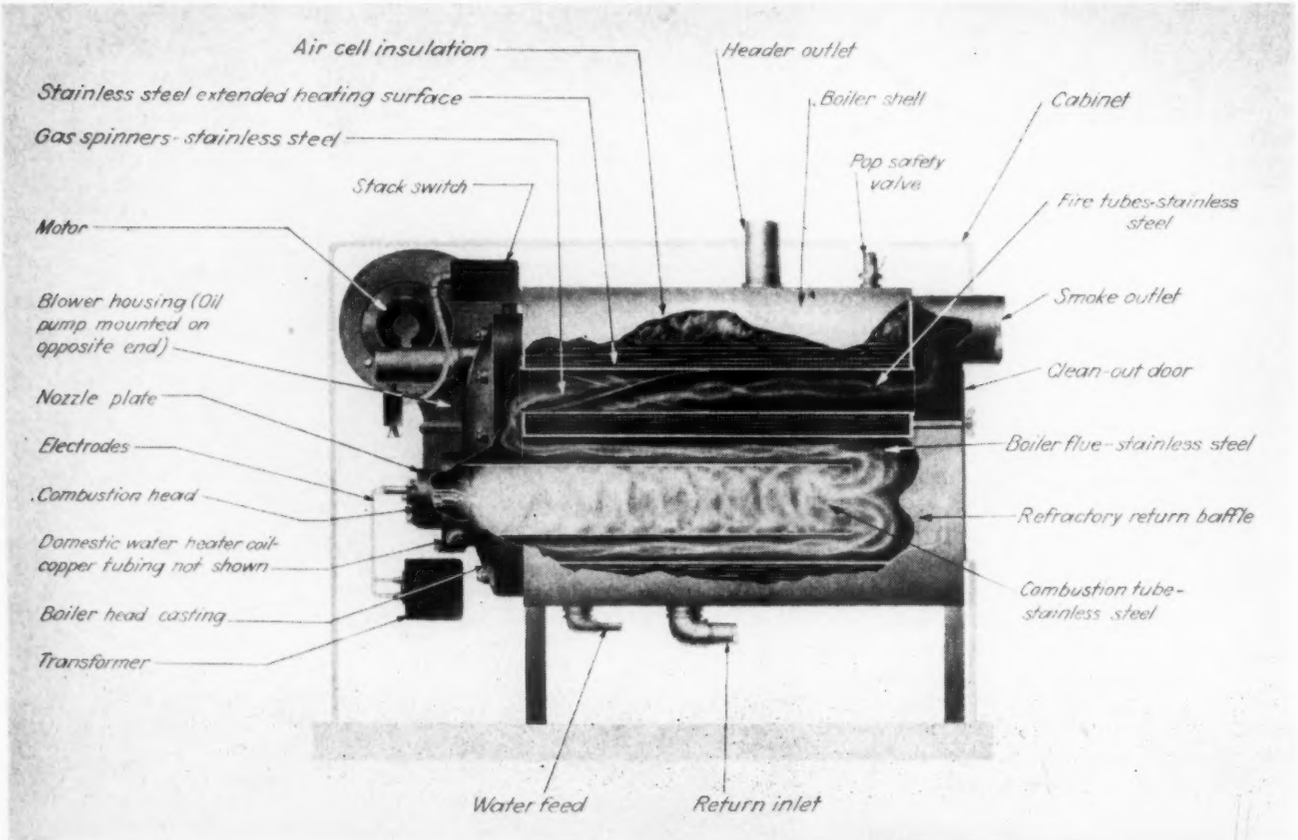

Fuel pump and injector: operated from camshaft and governed by bob weight located in camshaft timing gear
Injector stem has ribbed copper sleeve for cooling
Connecting rod: steel stamping with white metal steel backed bearing at big end
Overall dimensions with air cleaner, fuel tank, etc.:
Height 47¼"
Length 27"
Width 22¼"
Weight 535 lb.
DRIVE: Belt drive from pulley on either end of crankshaft, or alternatively, as half speed drive on extension of camshaft
STARTING: By hand with detachable starting handle operating at front end of camshaft
GENERAL EQIPMENT: Includes air cleaner, 4-gal. fuel tank, exhaust silencer to suit requirements

Combustion Chamber Surrounded by Water In Home Heating Unit

BOILER, oil burner, domestic hot water system and factory installed controls are combined in this compact home heating plant. Combustion tube and boiler flue and copper tubing for domestic hot water are built into the boiler so that no tank is required. Unit is housed in a cabinet 32 in. high, 24 in. wide and 42 to 52 in. long depending on 6 or 12 room capacity. Steam and vapor, or hot water system models are available. Starting cold the unit brings water to 180 deg. F. in 3 min., steam in 5 min., consumes 1.35 g.p.h. and in the average installation operates 2½ hr. per day. Capacity is 400 g.p.h. domestic hot water at 135 deg. F. and standing radiation of 670 sq. ft. of steam with 160,000 B.t.u. per hr. output. The Whirl-O-Magic Heating Unit is built by the Persiro Manufacturing Corporation, Newark, N. J.



Oil sprayed through the combustion head is burned in the combustion tube bringing it quickly to red heat. The gases reverse flow through the boiler flue, heating the boiler water and also cooling the combustion tube to maintain it at constant temperature. Hot gases pass upward to three 3-in. fire tubes. Each tube carries 72 exterior fins, 4½ in. by 5 in., that aid in heat exchange. Inside each tube a fixed gas spinner adds turbulence to further heat extraction. Stainless steel for all heating surfaces minimizes corrosion and, because of greater strength, permits thinner walls that give more rapid heat exchange.



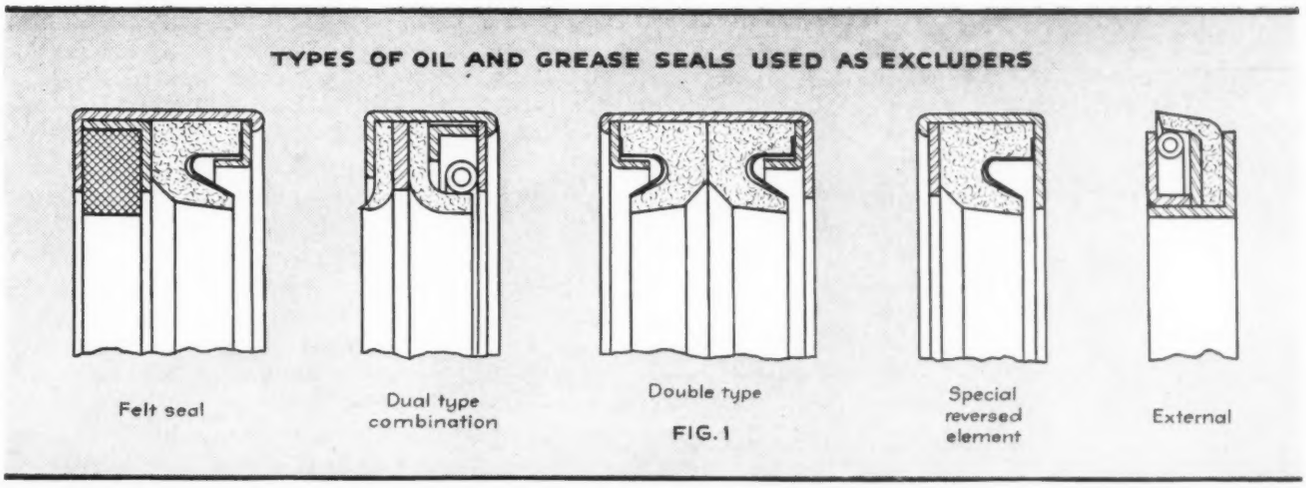


FIG. 1

BALL AND ROLLER BEARING SEALS

Proper Design and Application

E. P. STAHL
The Garlock Packing Company

Designs of common types of oil and grease seals for excluding foreign material from ball and roller bearings are shown. Proper application of different types of seals are discussed. Typical seal arrangements for industrial and automotive equipment are described.

OIL and grease seals in ball, roller and needle bearings must serve not only as lubricant retainers but also as excluders of foreign material. Properly designed bearing seals insure maximum protection of the bearing from the action of the grit, sand, mud and water that are prime causes of early bearing failure. Some of the simplest types of oil and grease seals designed to exclude foreign materials are shown in Fig. 1. Each type has a distinct field of application.

The "felt seal" or "combination felt type seal" is one of the most commonly used combination seals. It has a felt washer on the exposed face of the seal mounted in combination with a spring-loaded composition or leather sealing member. This seal has been used successfully in automobile, truck, tractor and trailer wheels and automobile transmissions.

The "dual type combination seal" is used both for lubricant retention and dirt exclusion in steel mill and general industrial equipment exposed to excessive quantities of foreign matter. This seal construction incorporates an auxiliary sealing member or wiper ring that acts in conjunction with the primary spring-loaded sealing member.

In the "double type" or "double flange opposed type" seal, the sealing members are mounted in a single metal case in reverse tandem. One member retains the lubricant in the bearing and the other excludes foreign matter. To reduce seal friction and wear, lubrication between the sealing members is provided by drilling holes centrally in the outer periphery of the metal seal case. This type of seal has been used extensively in steel mill and general industrial equipment. Where space is available, two single seals mounted in reverse tandem with metal spacer buttons between them are now used more generally than the "double flange opposed type."

In the "special reversed element seal," in which the sealing member is mounted in the reverse position in the metal seal case, a small clearance between the metal case and the shaft diameter is used as an extra safety measure. These seals are used in applications such as ash conveyors in stokers and center propeller shaft steadying bearings on trucks where considerable dirt and abrasive are present.

The "external" oil seal or grease retainer is usually fitted on the shaft collar and operates in the ground or machined bore of the housing, just the reverse of the conventional shaft type seal. It is used in applications where a press fit on the outside diameter is undesirable or impossible,

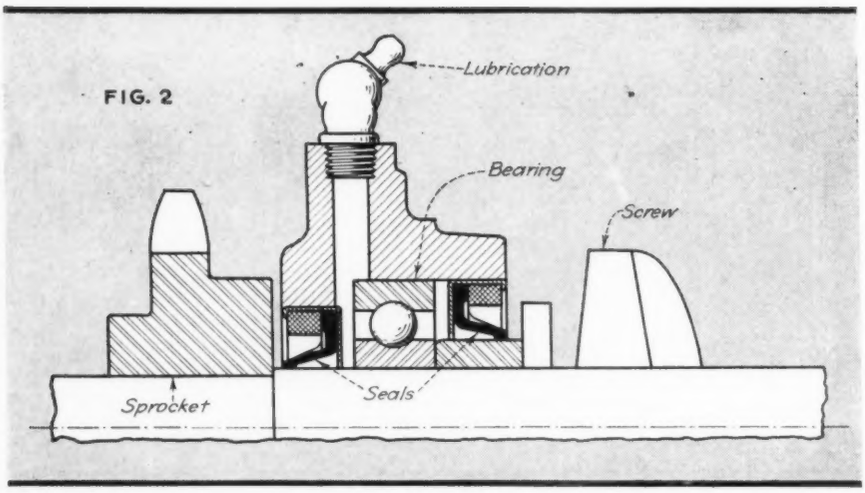


Fig. 2—Installation of conventional seals in screw conveyor of coal stoker.

as in designs in which the axle spindle or shaft is stationary and the housing revolves and removability of the latter over the bearing is necessary. This seal has been used in aircraft landing wheels, trailer wheels and tractor sprockets and, in small sizes, for certain reciprocating applications.

Unit or mechanical oil or grease seals with composition or leather sealing members are delicate precision units developed primarily for fluid sealing on highly finished shafts. The primary sealing member, spring loaded, should be protected by a felt, leather or composition wiper as an auxiliary unit whenever harsh abrasives are present. A metal baffle plate or metal slinger may be used as a supplementary protective member when unusual conditions are encountered.

Space limitations and considerations of design sometimes prevent the use of special seals or special wide seal combinations. In applications of this kind a single conventional type seal mounted with the sealing lip pointed outward toward the atmosphere is used. Thus mounted, the seal helps keep out dirt and water. The slight escape of lubricant past the seal keeps foreign matter out of the bearing. The lubricant also lubricates the seal and reduces seal and shaft wear. Fig. 2 shows a typical application of such an arrangement in a screw type conveyor of a domestic stoker.

Steel Mill and Industrial Applications

In steel mill roll neck bearings, oil contamination and oil leakage through imperfect oil seals must be prevented. Oil contamination by certain roll coolants has been known to dilute the oil and cause bearing failure. It is sometimes necessary to renew whole systems of bearing oil because of oil dilution.

A satisfactory oil seal design for roll neck bearings using both composition and leather oil seals is shown in Fig. 3. Two mechanical unit oil seals are mounted in tandem with the sealing lips pointed outward to exclude water, dirt and mill scale. Spacer buttons welded to the seal cases are used between the oil seals so that lubricant can be introduced between them. A slight amount of the lubricant leaks out and lubricates the seal and at the same time helps to keep out foreign matter.

Submerged bearings for electrotinning lines in steel mills have always been more or less of a "headache" to design engineers and mill operators. Roll slippage, scratched sheets, scored journals and bearings, and high maintenance costs for journal bearing repairs and roll grinding were always encountered with plain sleeve type bearings of the water lubricated type.

In plain sleeve type bearings on Bonderizing rolls, abrasive sludge scored both the journals and the bearings. This sludge also built up on the roll body to form a hard, smooth coating that reduced the frictional grip between the roll and the sheet and resulted in long shut down periods for journal and roll repairs.

To overcome these difficulties the "submerged counter pressure bearing" shown in Fig. 4 was designed. Two needle type roller bearings mounted in a self-aligning bearing housing or sleeve carry the radial load of the Bonderizing rolls. Two mechanical unit oil seals mounted in reverse tandem are applied to this bearing housing at the inner end adjacent to the roll head. The inner seal lip faces away from the bearing and the outer seal lip faces toward the bear-

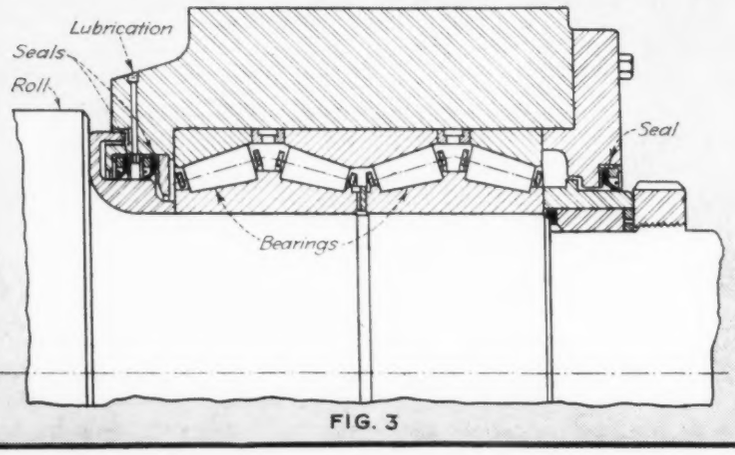


FIG. 3

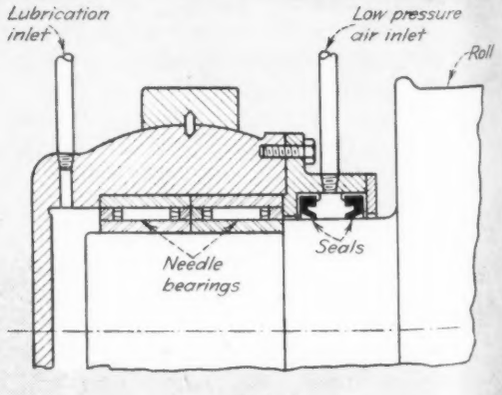


FIG. 4

ing to form an air pocket. An air pipe admits air at a pressure higher than the pressure of the liquid in the Bonderizing tank. This air pressure, of 5 to 25 lb. per sq. in., causes the lips of the synthetic rubber oil seals to hug the shaft and spread as the pressure is increased. The outer seal keeps the liquid out of the bearing and the inner seal acts as extra protection if the air pressure should fail or the air pipe break. The bearings are lubricated through the pipe at the outside end of the bearing housing as indicated.

The "submerged counter pressure bearings" on the rolls of electrotinning lines have proven very successful. Full line speeds have been maintained for a period of six months or more with practically no maintenance costs whereas with the old sleeve type bearings it became unprofitable to run at the end of three days.

It is believed that these "counter pressure bearings" can also be used advantageously on cleaning lines and pickling lines in steel mills. Their use may be extended to certain textile, marine and steel mill roll neck applications where the exclusion of liquids and foreign matter from bearings is important.

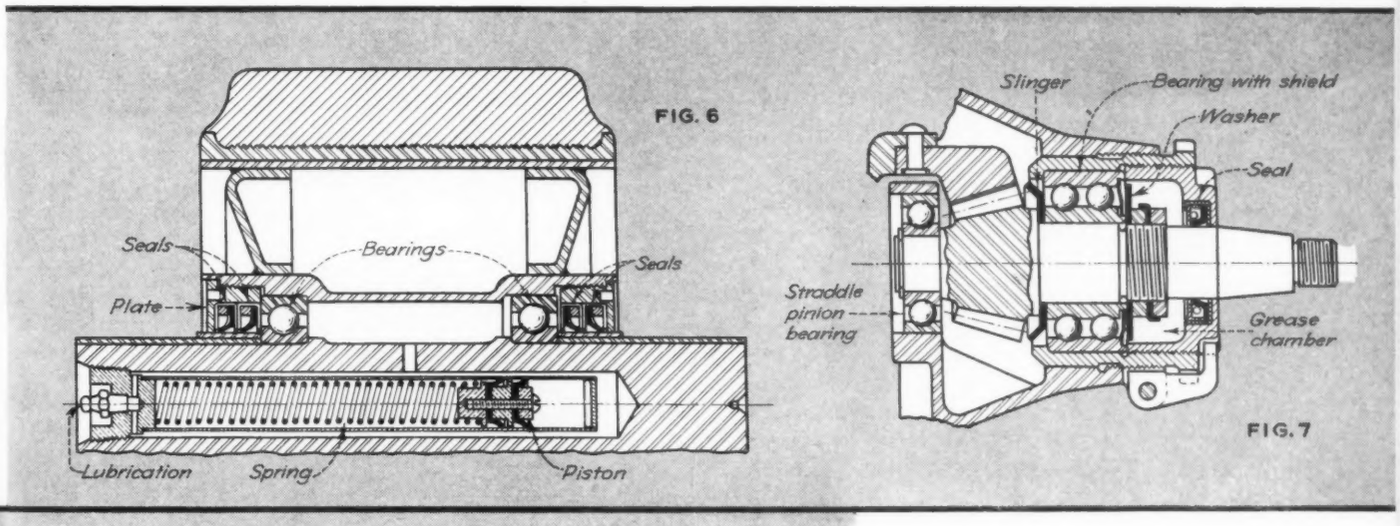
Oil Seals for Vehicles

Two of the most troublesome oil and grease seal exclusion applications in military vehicles are in the track links and in the bogey wheels in crawler type vehicles such as gun mounts, tractors and half-tracks. The bearing and seal arrangement used by the Germans in the links of their ¾ ton tractors and half-tracks is shown in Fig. 5. The superior performance of these tractors and half-tracks is attributed to the links, which are equipped with needle roller bearings. The needle bearings in these units are sealed with Perbunan synthetic rubber seals mounted with the sealing lips pointed outward to exclude grit, sand, mud and water. According to captured German crews these links were never lubricated in the field since the factory lubricant was adequate.

The bearing and seal arrangement shown in Fig. 6, which was used for the bogey wheel of the famous "Water Buffalo"—an amphibious tractor used by the U. S. Army and Navy, was highly satisfactory. Ball bearings are mounted in combination with tandem synthetic rubber seals with the sealing lips pointed outward toward the atmosphere. The spring-loaded piston with leather washers in the bogey wheel gudgeon or axle helps keep out water. When packed with grease, the pistons push grease past the seals. The escape of grease not only helps to exclude water, sand and mud from the bearings but also lubricates the seals and reduces seal wear.

A bearing and seal arrangement used successfully on the bevel pinion shaft on automotive rear axles is shown in Fig. 7. The housing is sealed with a spring-loaded, leather or composition rubber seal.

The greater portion of the grease in the grease chamber remains static



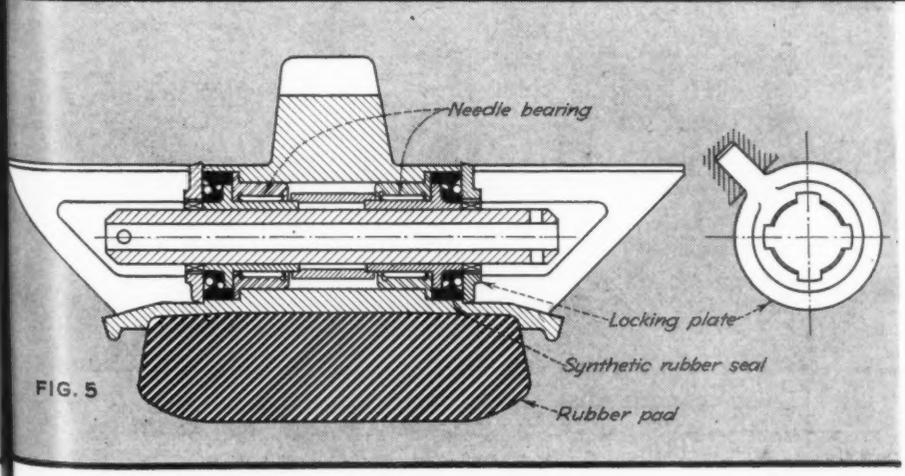


Fig. 3—Tandem mounting of oil seals for steel mill roll neck bearings.

Fig. 4—Counter pressure seals for bearings of Bonderizing rolls.

Fig. 5—Seals for track link of German ¾ ton tractors and half-tracks.

Fig. 6—Bearing and seal arrangement for Bogey wheel of "Water Buffalo" amphibious tractor.

Fig. 7—Bearing and seal arrangement of the bevel pinion shaft of automotive rear axles.

and is not agitated or churned by the rotating shaft or coupling. However, a small part of the grease will rotate with the shaft thus channeling a labyrinthian passage. Any foreign matter passing through the spring-loaded housing seal is trapped in the grease contained in this chamber.

A cross-sectional view of a bearing and seal arrangement used on the rotors of a magnetic separator is shown in Fig. 8. Two single unit mechanical seals, mounted on each side of the self-aligning roller bearings, have provision for injecting grease between them. These machines handle abrasive sand and are greased only weekly. Some of them have been in operation eleven years without any necessity for replacement of the bearings or seals.

A special composition seal applied to a self-aligning roller bearing is shown in Fig. 9. This seal, which takes care of maximum misalignment, is designed to contact a spherical shaft collar at a tangent and has been very effective as a dirt and water "excluder."

A sectional view of a bearing and seal arrangement in the guide roll of a road roller is shown in Fig. 10. The seal is mounted with the sealing lip pointed outward to exclude dirt and water. Any slight escape of grease under the heel of the seal not only helps to exclude foreign matter from the bearing but also lubricates the wear washer.

A composition rubber detachable seal for a sealed ball bearing used extensively in aircraft controls is shown in Fig. 11(*A*). This seal consists of a synthetic rubber disk held in the outer bearing ring with a split metal retaining ring. This seal, which operates on the "air cleaner" principle, has proven effective both for excluding dirt and water and for retaining the lubricant in the bearing.

The non-detachable seal shown in Fig. 11(*B*) has been used with good success for a number of years in the rear wheels of several popular makes of automobiles. It consists of a felt faced rubbing seal carried in a metal slinger attached to the inner bearing ring between the annular opening formed by two sheet metal parts fastened to the outer bearing ring.

In the past years much stress was placed on seals for sealed ball bearings as lubricant retainers. Recently it has been found that often the exclusion of dirt and water is far more important than the retention of grease. A small amount of grease can leak out and still leave enough to take care of the bearing for a long time.

THE AUTHOR is indebted to the following firms for contributions of material for this paper: The Timken Roller Bearing Company, Canton, Ohio; The Fafnir Bearing Co., New Britain, Conn.; New Departure Div., General Motors Corp., Bristol, Conn.; Navy Department (Bureau of Ships), Washington, D. C.; W. T. Hurtt, Pittsburgh, Pa., Chicago Rawhide Mfg. Company, Chicago, Illinois; Marlin-Rockwell Corp., Jamestown, N. Y.; SKF Industries, Inc., Philadelphia, Pa.

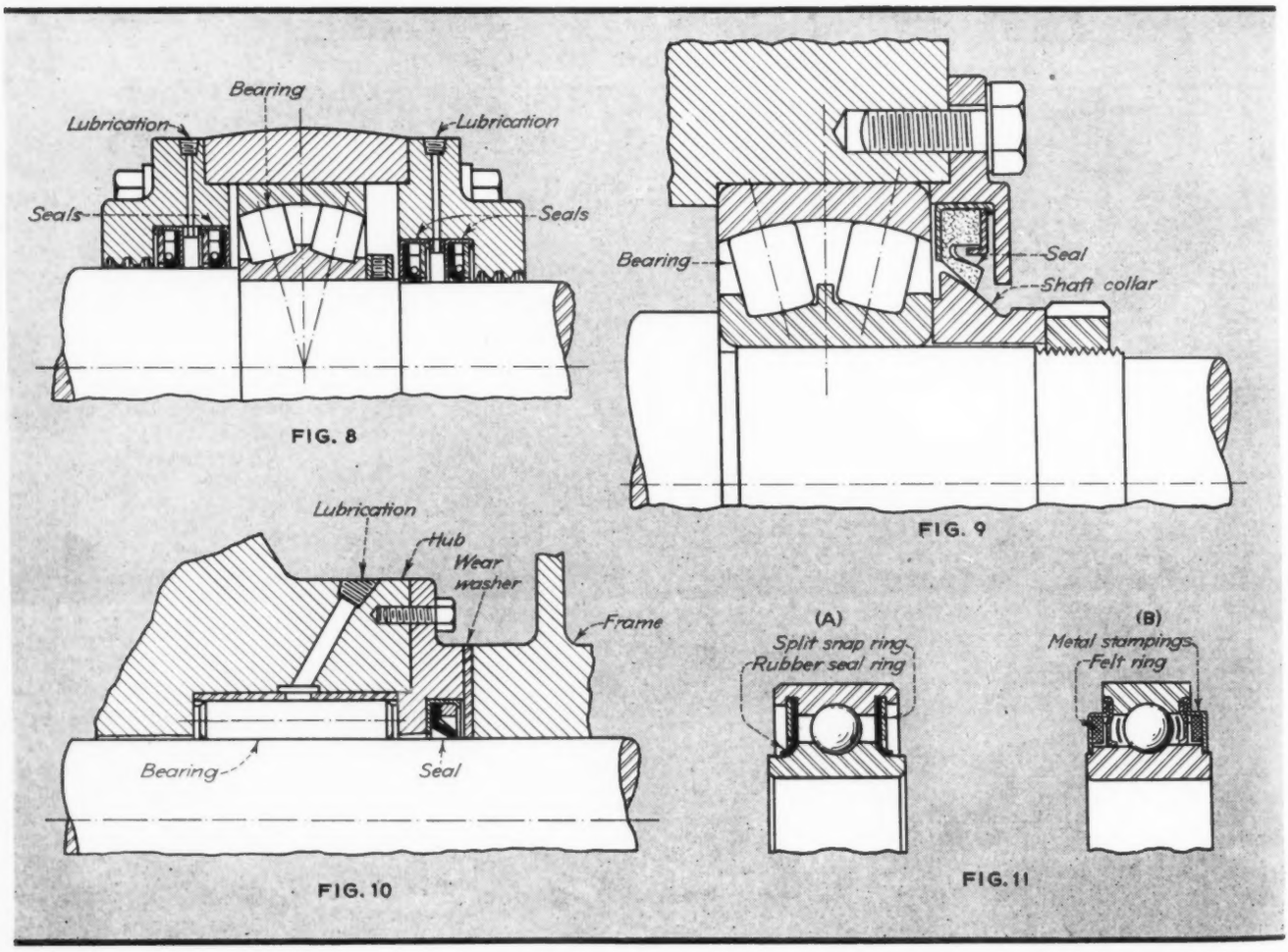


Fig. 8—Bearing and seal arrangement of rotor shaft of magnetic separator. Fig. 9—Special seal arrangement for self-aligning roller bearings. Fig. 10—Bearing and seal arrangement of guide-roll of road roller. Fig. 11—Detachable and non-detachable seals for sealed ball bearings.

Progress IN REVIEW

PLASTICS

Using a mixture of powdered magnetic alloy with either thermosetting or thermoplastic resins, it is now possible to produce shaped magnets more economically than by the usual metal casting and grinding operation. The magnetic energy of the molded magnet, as mentioned in *Modern Plastics*, Feb. 1947, is approaching that of an all-metal magnet. In some cases it is only 25 percent less than that of a cast magnet of the same shape and working area. The use of metal-plastic mixtures is being investigated for possible applications in fields other than that of the molded magnet.

Preheating molding powders by the use of live steam is becoming increasingly important. This technique seems to be a less expensive way of getting uniformity and a high production rate, comparable to the use of high frequency preheaters. It has been reported that one supplier of high frequency equipment is now ready to supply steam preheaters. In line with this is the report that the use of electronic, high frequency heaters to warm phenolic laminates prior to punching has virtually eliminated rejects of punched insulator parts. As mentioned in the Feb. 1947 issue of *Plastics World,* the use of these preheaters has increased the production rate and decreased the over-all cost. In this particular operation, hot plates usually serve as heaters, and the live steam preheater could not be applied because of the adverse effect it would have on the electrical properties.

Phenolic resins are being used increasingly in oil field operations. Loosely packed sand has been one of the major problems in the successful operation of an oil well. Frequently the sand moves into a well bore or casing in sufficient volume to halt or seriously reduce the flow of oil. In other cases it forms solid plugs that require shutting down the well. Resins are now being used to bond the sand in place, as outlined in *Industrial and Engineering Chemistry,* Feb. 1947. Since the flow of oil through the sand is important, the resin must bond the sand in such a way that the over-all permeability of the formation is unchanged. This technique has proved successful in 80 percent of the cases where it has been tried.

A channel shape of laminated single-faced corrugated-cardboard impregnated with a phenolic resin, a polyester resin, wax or sulfur has recently been developed. These pallets have already found extensive use in the shipping of aluminum tubing and trimming, and forming inexpensive tree-guards, according to the Feb. 1947 issue of *Industrial and Engineering Chemistry.* Its application for floorings, walls, roof decks and reinforcing concrete structures is being investigated.

Wood bonding operations have been speeded up by the development of a phenol-type high frequency adhesive. It is claimed in *Chemical Industries,* Jan. 1947, that this adhesive will not arc when electrodes come in contact with the squeeze-out of glue, or with the glue line itself. Because of this, maximum power can be used to provide quicker curing. High frequency heating should become applicable for many new wood bonding operations.

Direct molding of pieces from thermoplastic powders will usually give a smooth, lustrous finish. Machined plastic parts ordinarily will not yield as good a finish and must be buffed to reach a high gloss. Expensive machining techniques have been developed which will give a good finish, but a new process discussed by Raymond Nauth in *Industrial Plastics,* Feb. 1947, will eliminate this extra expense, and the extra steps. The parts are machined by ordinary low-cost means and the fine finish is then obtained by dipping the part in a chemical solvent. When dipping more than one part they must be kept separated to avoid sticking. Each type of thermoplastic material requires a special solvent. Acetone, chloroform, styrene monomer and chlorinated ethers are commonly used; modified by the addition of a small amount of castor oil.

Coloring of plastics or resins by commercial methods, now in use, has been attended by certain difficulties. The dye or pigment has been mechanically added to the plastic and it is difficult to match colors, even in the same batch. Some of these colored plastics have faded because of exposure to light, heat or chemical corrosion. A new principle has been discovered; one that chemically combines the dye with monomer or polymer so that the dye and the plastic become an inseparable molecule. A review of this process by William Penn in *Plastics* (British), Jan. 1947, points out that it has already been successfully applied to polystyrene and phenolic molding materials, as well as to some resin filaments used in fabric production. The dye can be introduced during resin polymerization or after the resin is complete. The chemical combination can be made in several ways; the most interesting of which is the case where the dye molecule copolymerizes with the resin monomer.

Phenolic laminate production is about equal to that of molded phenolics, and equivalent to about 20 percent of zinc production, or ⅓ of 1 percent of steel output. As outlined in *Modern Plastics,* Feb. 1947, about 30,000,000 lb. of phenolic resin, dry basis, are used annually in the production of laminates. Of this amount, 45 percent is used for electrical insulation, 40 percent for mechanical, structural and chemical applications, and about 15 percent is used for decorative items. In line with this is a discussion, in the same magazine, on the thermoplastic cellulose acetate and ethyl cellulose laminates. These base resins are more expensive than the competitive thermosetting materials but there are certain advantages to them. Thermoplastic laminates have greater toughness, better color possibilities, and

greater ease of fabrication, especially when deep drawn. The biggest disadvantage is the high cost of the resin with the resulting high waste cost. At this stage of development thermoplastic laminates have poor weathering resistance and are subject to a high water absorption rate unless the edges are sealed. A thermoplastic laminate with 70 percent of expensive resin has no better electrical insulating properties, and has a higher water absorption rate than a phenolic laminate with only 50 percent expensive material. Experiments are in progress to determine the suitability of thermoplastic laminates in the construction of suitcases, lamp shades, expendable gas tanks, fairings for airplanes and similar consumer articles.

Hobbing has been used extensively to produce multiple-cavity molds but its cost could not compare with machining for single-cavity molds. John Hohl in *Industrial Plastics,* Feb. 1947, has stressed the growing use of hobbing even in single-cavity molds. The improvement of hob steels and the refinements in hob press design have contributed to the extended use of the hobbing technique. Since the final finishing step is eliminated in a hobbed mold, the cost of such molds is now lower than for machined molds. Today, intricate designs are possible for low-cost articles which could not have been made in the past. The hobbing process is especially useful whenever identical or interchangeable products are required or when raised characters are desired in the molded part.

Stresses set up in transparent solid plastic materials while in high voltage fields prior to, at, and after dielectric failure can now be studied by use of a technique outlined by John Delmonte in *Modern Plastics,* Feb. 1947. This process is very similar to the photoelastic analysis of materials under mechanical strain. A source of polarized monochromatic light and a Polaroid viewing screen enable the observer to witness changes within the material while voltage stress is being developed. The technique is new and has been applied with unusual success only to cast phenolics which have relatively high current leakage and low dielectric strength.

Butyl rubber inner tubes have been shown by severe over-the-road tests to hold air 8 to 10 times better than natural rubber tubes. Because of the more uniform tire pressure, tread-life of tires increased 10 to 18 percent, respectively, when measured at speeds of 60 and 40 m.p.h. Butyl inner tubes age better than natural rubber tubes and are more resistant to punctures and long-life failure. These test results, outlined in the Feb. 1947 issue of *Industrial and Engineering Chemistry,* indicate greater safety and longer wheel life for automobiles in the future.

Research into the infinite combinations possible with plastics is slowly making progress. Every day brings news of a new combination that has one or more advantages over those already in use. As reported in *Industrial and Engineering Chemistry,* Feb. 1947, one group of research workers has completed the copolymerization of 214 different compounds with butadiene to yield products improved in oil resistance, freeze resistance, resiliency, and low heat build up. In line with this is the report that the Office of Rubber Reserve has approved the production of 360 experimental polymers for evaluation, on a large scale, of processing and vulcanizing properties.

GR-S type synthetic rubber constituted about 90 percent of all synthetic rubbers produced in the United States during the war. A combination of price and properties indicated that this synthetic rubber would not be competitive with natural rubber except in minor special applications. This indication has been borne out, up to now, by the reluctance of private industry to purchase the government owned plants; however, the price differential is being gradually diminished and the properties are being improved by modification so that competition may soon be on an even basis in general applications. One of the outstanding modifications of GR-S rubber is the type, GR-S-X285. Recently renamed GR-S-60, this one is not the only approved type of GR-S rubber. The Jan. 1947 issue of *India Rubber World,* states that there are dozens of approved variations which have made up almost half of the total synthetic rubber production over the past few months. The variations include changes in emulsifying agents, coagulating agents and the addition of cross-linking agents as in GR-S-60. Some of the improvements are an enhanced tackiness, faster processing qualities, non-staining and non-discoloring properties, lower water absorption rates and the easier production of latices with high solid content. These improvements, plus higher abrasive resistant qualities, indicate a large use of these synthetic rubbers in the manufacture of brakelinings and shoe soles.

Viscosity and spectroscopic studies, as reported in the Feb. 1946 issue of *Industrial and Engineering Chemistry,* have confirmed the differences in mechanisms of heat aged natural and GR-S synthetic type rubbers. These differences were predicted by earlier studies of the tensile strength, elongation, modulus and hardness over a long period of time. It is now evident that aging inhibitors satisfactory for one type may actually be catalytic agents for the other.

Crude rubber based resins are again going into production. The shortage of crude rubber during the war temporarily suspended the manufacture of these resins. Some synthetic rubber based resins are also being produced. As indicated in *Modern Plastics,* Feb. 1947, there are several applications for these resins. They are finding use as paper coatings, paints, shoe soles, quick drying inks, and rubber reinforcing.

Precoagulation blending of carbon black into synthetic latex will produce a more homogeneous product with improved wearing qualities, at a lower cost, than is now possible. West coast tire manufacturers add the carbon black to the finished rubber by the laborious and expensive milling process. *Chemical and Engineering News,* Feb. 10, 1947, reports the beginning of construction of a premixing unit which is designed to blend 2,500,000 lb. of rubber and lamp black, monthly. The blend will be coagulated, filtered, dried and then baled for shipment to the ultimate tire manufacturer.

NONFERROUS METALS

Monel or nickel double wall tubing is now supplied in continuous lengths up to 100 ft. Used during the war for fuel and oil lines on aircraft engines this tubing is now being used in the food and beverage industries where corrosion and harmful metallic contamination must be avoided. The tubing is made, according to the Jan. 13, 1947 issue of *Steel,* by electrolytically coating a strip of nickel or monel with a bonding metal, rolling the strip into a double walled tube and bonding it by inductive brazing in a continuous operation. The use of a scarf edge insures uniform wall dimensions. Tubing made of either metal is available in standard sizes from 3/16 to 5/8 in. outside diameter.

Aluminum, the only major metal which is cheaper now than before the war, ranks second to iron in terms of volume produced. The largest percentage of aluminum is now being used in the form of architectural shapes. The *Saturday Evening Post,* Feb. 8, 1947 shows a house that has shingles and clapboard made of aluminum. Because of its rust-

proof, fireproof, vermin and termite-proof qualities, aluminum is being used in corrugated and snap-seal roofing, weather-board siding, and other building items. When using these building materials care must be taken to protect joint surfaces; particularly where the aluminum is in contact with iron and steel. Heat-treatment of aluminum alloy 75 S has again been speeded up. It originally required 24 hr. to effectively treat this alloy, but, because of working shifts, a treating cycle of two 12 hr. steps was developed. An 8 hr., one shift, treatment, described by J. A. Noch, Jr. and A. C. Wooll in *Iron Age,* Jan. 30, 1947, heats the material for 3 hr. at 250 deg. F., cools to below 100 deg. F., and reheats at 325 deg. F. for 3 hr. The mechanical properties of the treated alloy are said to compare favorably with those obtained by the standard heat treatment.

A high strength aluminum sand casting alloy contains 11.2 percent of magnesium, 0.4 percent boron, and 0.2 percent beryllium as the principal alloying elements. In the heat-treated condition the alloy will develop a minimum tensile strength of 55,000 lb. per sq. in. with an average value in excess of 60,000 lb. per sq. in. as compared to a minimum tensile strength of 40,000 lb. per sq. in. for the similar magnesium-aluminum alloy No. 220 which contains no beryllium or boron. The alloy was developed from studies begun during the war on the effect of adding small amounts of other materials to the basic magnesium-aluminum alloy. According to Harold Knight in the Jan. issue of *Materials and Methods,* the addition of beryllium was found to suppress the segregation of magnesium during cooling, while degassing of the molten metal with boron trichloride gas just prior to pouring eliminated porosity. This alloy, Almag 55, has been used succesfully in plaster molds. It is stated that the alloy is machined without difficulty, preferably with carbide-tipped tools at high speeds.

Results of American research on the metallurgy of magnesium during the war years are now available in the form of 45 reports which can be procured from the Office of Technical Services. The reports cover a comparison of two American sand casting alloys with two European alloys; new methods of melt preparation; fatigue properties of magnesium alloys and structures; methods to improve the physical and stress corrosion properties of magnesium alloy sheet; and test results which show that primers containing zinc-yellow pigment are better than clear primers as protective coatings for magnesium alloys. In line with this is a discussion by R. T. Wood in the Dec. 1946 issue of *Light Metal Age,* of the need for protecting the surface of magnesium alloys against corrosion. Definite steps must be taken to prepare the surface, to clean it, and to apply the paint or chemical coatings. This becomes more important because of the expanded production of magnesium, and since it is the only metal for which the raw material is still available in unlimited quantities.

Two brazing alloys, containing 35 and 45 percent silver, melt at 1,295 and 1,145 deg. F., respectively. These alloys are less expensive than those in use now, and can be used for joining ferrous, nonferrous, and dissimilar metals. Because of their low melting points they can be used where the work must be protected against warping and heat damage.

Oxidation-resisting materials can be cut by a process similar to the Navy's underwater torch method. A hollow, coated electrode strikes an arc on the work and the metal is cut by an oxidation reaction with resultant melting of the metal. In *Materials and Methods,* Jan. 1947, H. R. Clauser discusses the use of this method with either a.c. or d.c. arc welders. This process can be used to cut nickel, Monel, cupro-nickel, copper and its alloys, and aluminum; as well as alloys and stainless steels, cast iron, and carbon steels. Sections up to 3 in. in thickness have been cut.

The bright-plating of copper, as described by Harold Leever in the Jan. 1947 issue of *Materials and Methods,* will reduce the cost and time for nickel and chromium plated parts by eliminating the drying, polishing and reracking operations now required when conventional methods of copper base-plating are used. The part to be plated is agitated in a standard cyanide plating bath to which has been added 2 percent, by volume, of a brightener solution. If more convenient, the bath can be agitated instead of the part. The plating bath is said to operate at 100 percent efficiency; and at a current density of 20 amp. per sq. ft. it will deposit 0.002 in. of copper per hour.

Hard chrome plating can be used to build up crank shafts and ring gears machined undersize, as well as for prolonging the life of gages and tools. All Johansson gage blocks are hard chrome plated to reduce wear as are snap, plug, ring and bar gages and arbors, according to Herbert Chase, *Iron Age,* Jan. 30, 1947. Before plating, the material is electrolytically cleaned for 30 sec. by reversing the current, and then plated in a bath containing 32 to 55 oz. per gal. of chromic acid and 1/100 of this amount of sulfate. The chrome builds up at the rate of 0.001 in. per hr. Plates from 0.008 to 0.012 in. are applied. Plating in cavities is kept to 0.0005 in., where wear is not a factor.

Zirconium is finding increased use as an additional element in magnesium-zinc alloys. The most pronounced effect of the added zirconium is that of increasing the extrudability of the alloy; especially in those having a high zinc content. J. P. Doan and G. Ansel in *Metals Technology,* Dec. 1946, state that magnesium-zinc alloys are tougher and less notch sensitive with small quantities of zirconium included. In the wrought alloys, its use tends to develop a fine grain material that gives a high tensile strength and a higher ratio of compressive strength to tensile yield strength.

Beryllium copper strip which has sufficient ductility to permit fabrication like any cold-rolled spring material, such as phospher-bronze or nickel-silver, is now being used. The coil stock is precipitation hardened by the producer and requires no further heat treatment after fabrication, as mentioned in *Materials and Methods,* Jan. 1947.

For many parts, the quality of the surface finish may have a far greater influence on the life of the part than either its composition or physical properties. Many methods are used to measure the quality of a finished surface. In a discussion of the advantages and disadvantages of the various methods, J. A. Broadston, *Steel,* Jan. 3, 1947, concludes that none of the present generally acceptable criteria correlate finish perfection with part performance.

Electroforming, developed by Prof. Jacoby, in 1839, who found that a surface could be copied by depositing copper upon it, has been confined to electrotyping and the formation of half-tones. Now, as discussed by E. A. Ollard in *Metal Industry,* Jan. 3, 1947, it is being used for the production of machine parts, radio parts, molds for plastics, the reproduction of surface standards and many precise radar parts. However, its use is still limited by the rate at which the metal is deposited.

When welding brass, pre-heating of the parts to 400 deg. F. is desirable if the brass has a low zinc content. If the zinc content is high, the brass should be pre-heated to 800 deg. F. H. Hose discusses this, and the factors to be considered when welding silicon bronze, in the Feb. 1947 issue of *Machinery.* Beryllium copper should be solution heat-treated at 1,450 deg. F. after welding to insure response to aging.

RECORDING MAGNETIC DETECTOR

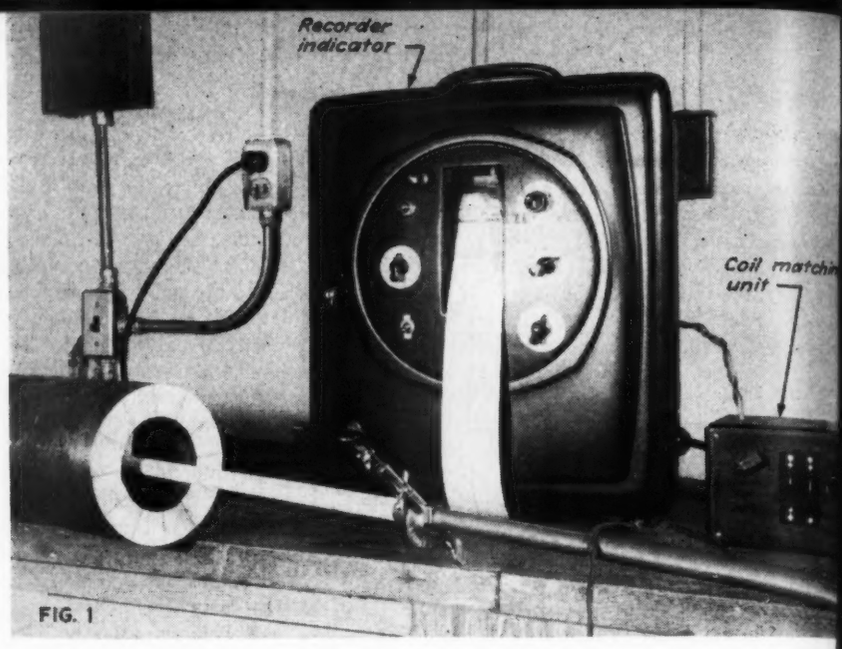


FIG. 1

Locates Flaws in Ferrous Metals

C. H. HASTINGS
Watertown Arsenal, Watertown, Mass.

DETECTION of cracks and other flaws on or near the interior surfaces of hollow parts such as cylinders and gun tubes is particularly difficult because of the inaccessibility of the surfaces. A new type of magnetic flaw detector has been developed to overcome this difficulty. This device, which operates on the principle of measuring the magnetic leakage caused by the presence of flaws in magnetized steel or other ferro-magnetic materials, provides a dependable method of non-visual flaw detection.

The basic principle of this detector, although new to non-destructive testing, has found numerous applications in the electrical field, an outstanding example being the filter choke used in electronic power supplies. A magnetic detecting coil is connected into an electrical bridge circuit as shown in Fig. 2. This type of circuit makes possible a balance between the detector coil and another identical coil. The detector coil unit consists of a small coil wound around a core material of high magnetic permeability. Changes in the magnetizing force applied to the core cause proportional changes in the inductance of the coil with respect to the alternating current flowing through it.

A flaw in a magnetized part causes a magnetic change in the detector coil by increasing the magnetic flux density at the surfaces as shown in Fig. 3. Because the other coil is unchanged magnetically, the system becomes unbalanced. The amount of unbalance is indicated by the milliammeter. The magnetic leakage, caused by the presence of flaws, can be detected without the necessity of having the coil in motion. Extensions on the core of the detector coil provide magnetic contact between the core and the piece being tested and insure maximum pickup of the leakage field. An amplifier connected between the bridge and the meter may be used to magnify the unbalance as much as desired. Thus a slight change in the magnetic field at the detector coil can cause a relatively large deflection of the indicating meter.

The part to be examined is magnetized either by passing a direct current through the part or through a cable threaded through or wrapped around the part. The magnetizing current and the sensitivity of the detector can be adjusted to permit flaw detection either while the current is flowing or after application of the current and removal of the cables.

For the inspection of the bores of tubes, the detector head, Fig. 4, is designed to prevent the detector coil from tilting or turning and thus altering its contact with the surface of the metal. Two copper wires wrapped around a cylindrically shaped piece of laminated plywood serve as bearing bands to give a reasonably good fit without wear to the surface being examined and without too much friction. A hole bored in the side of the piston-like head accommodates the detector coil and a helical spring. This spring, pushing on the coil, provides uniform contact pressure with the bore surface during test. Another hole bored through from one end of the head to the other contains the electrical leads to the coil. The electrical leads are brought out through a long tubular handle, fastened to the back of the head by means of which the assembly can be manipulated through the bore.

Many different types of instruments are suitable for the electrical components, apart from the detector head. Recording milliammeters, available from commercial instrument makers, embody several desirable fea-

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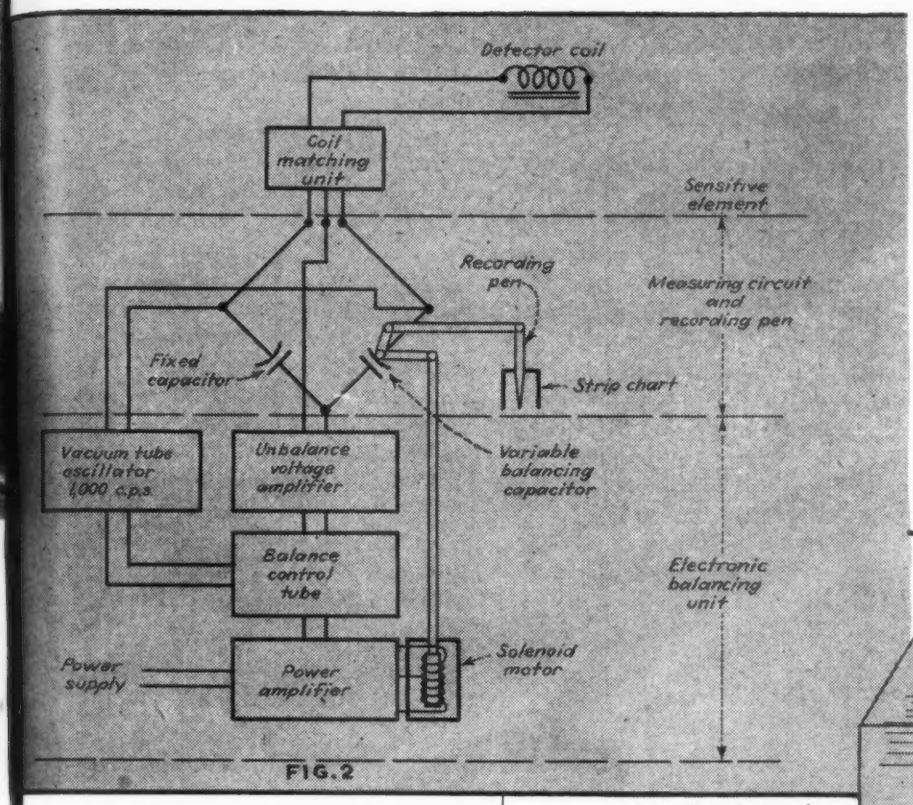


FIG. 2

Fig. 1—A complete magnetic flaw detection unit set up for manual manipulation of the search coil. The scale on the manipulating handle and tube locate position of flaws.

Fig. 2—Electric circuit diagram for magnetic flaw detection unit.

Fig. 3—Magnetic field disturbance caused by presence of flaw.

Fig. 4—Design of detector head assembly for inspecting bores.

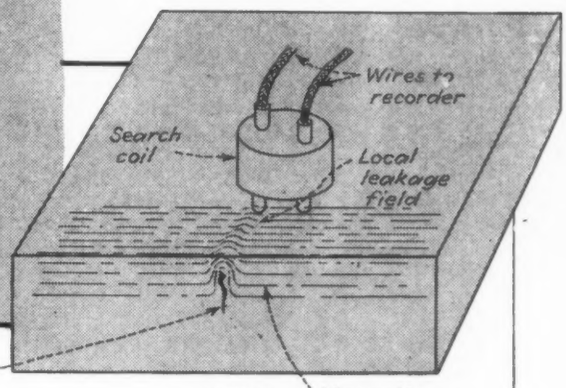


FIG. 3

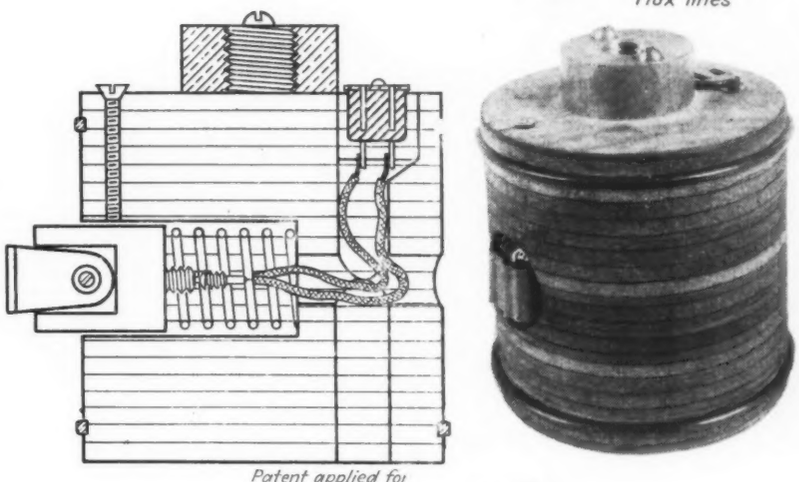


FIG. 4

tures. A typical instrument, such as shown in Fig. 1, contains a narrow strip chart upon which a pen and ink record of instrument variations can be made. By operating a switch, a neon flasher lamp may be substituted in place of the recorder. Although the advantages of a permanent chart record of inspection operations are obvious, the rate of inspection possible with an electromechanical recording pen is limited by the lag in the instrument. For rapid, more cursory inspection, the inertialess neon lamp offers advantages because of its quick response. Sensitivity of response is adjustable over wide limits for both the neon lamp and recorder.

The small box to the right of the recorder shown in Fig. 1 is for matching the electrical characteristics of the detector and balancing coils before a test is made. When matching the characteristics, the detector coil is placed in inspection position and the two coils are balanced to give zero deflection in the recorder.

For inspection on a production basis, tubes are magnetized by means of a direct current passed through a cable threaded through the bore of the tube. A magnetizing force of 1600 ampere-turns is adequate to permit the detection of near surface flaws. In such inspection only the residual magnetism is used. An automatic mechanism pulls the detector head through the bore after this cable has been removed. The entire surface of the bore can be examined with one pass by mounting the tube on end rollers and turning it slowly as the detector is drawn through the bore, and by adjusting the rate of turn and forward motion to suit the size of the detecting coil. By synchronizing the pulling mechanism with the chart drive of the recorder, the exact location and extent of bore cracks can be determined by an examination of chart records. When the neon indicating lamp is used in place of the recorder, the addition of a linear and a circular scale to the cable or rod used to pull the head allows the operator to determine the longitudinal and clock position of flaws.

In the inspection of flat surfaces, the parts are magnetized either by passing the direct current through the metal or through a cable wrapped around the part. The direction of

current flow or cable wrapping is adjusted to produce a magnetic flux approximately perpendicular to the direction in which the flaws are most likely to be found.

Detector Development Tests

The initial development tests were carried out on two steel plates butted together and welded across the ends as shown in Fig. 5. To magnetize the plates a direct current of 200 to 400 amp. was passed through the plates parallel to the separation between them. After magnetization, the search coil, connected to the bridge by means of a flexible cable, was placed on one plate at some distance from the separation and the bridge adjusted to balance. When the detector coil was moved over the gap, a deflection of the meter was noted. When the coil was stationary over the gap the meter remained in its deflected position until the coil was moved.

A second test was carried out on a block of steel 3 in. thick with a quench crack on one face. By grinding off successive small layers of this face and testing between grinding operations, a surface was reached where the crack caused only a barely perceptible meter deflection. A measurement of the crack remaining indicated it was about 0.05 in. deep.

Other tests were made on a hollow cylinder, about 20 in. long and 1¼ in. wall thickness, that had previously failed by cracking in a hydrostatic pressure test. The crack was visible for about ½ in. of length on the outside surface.

This tube was magnetized by a central conductor threaded through the bore. Dry Magnaflux powder was dusted onto the exterior surface while maintaining this magnetizing force. The powder pattern formed, about 4½-in. long, was narrow and sharply defined at the point where the crack came to the surface and broadened out to a wider pattern fading off at both ends of the visible crack, indicating a variation in the distance of the crack from the surface.

Exploration by means of the magnetic detector coil also indicated the presence of the crack throughout a length of 4½ in. The magnitude of meter deflection was greatest at the point where the flaw came to the surface and decreased on either side of this location. Thus the results obtained with the magnetic detector coil compared favorably with those obtained from the Magnaflux test on both the surface and sub-surface portions of the crack.

By sectioning the cylinder longitudinally after completion of the tests, it was found that this crack was about 5 in. long on the inside surface. Thus, as viewed on a section through the wall, the crack was a triangle having its base on the inside surface and its apex at the exterior surface.

Preliminary magnetic inspection of another tube, which had been rejected during manufacture because of two flaws suspected upon borescope examination, revealed more than two indications of the type asociated with crack-like flaws. Some of the smaller recorder deflections seemed to be coincident with rusted areas. After these areas were removed by a rough machine cut, retesting the clean bore surface of the tube showed four distinct crack-like deflections. A re-examination of the bore surface with the borescope showed four unmistakable cracks. The breaking of the metal chip during machining left a shiny edge on one side of each crack that could be seen readily with the eye. It should be pointed out that more than four crack-like indications were obtained when testing the original surface with the magnetic detector whereas only two cracks could be suspected on borescope examination.

Typical chart records taken from this tube are shown in Fig. 6. The lower sensitivity used in run (*A*) accounts for the smaller amplitude of indication. Instrument lag, accompanying a relatively rapid rate of detector head movement in run (*B*) caused the greater width and closer spacing of indications in this run.

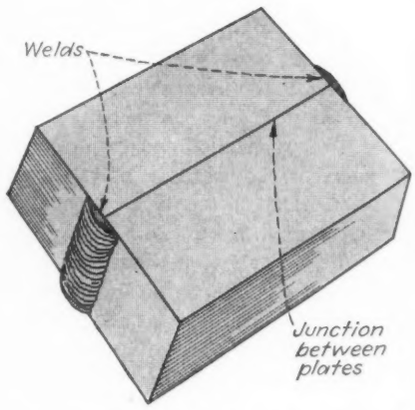


Fig. 5—Butted test piece used in initial development test of magnetic flaw detector.

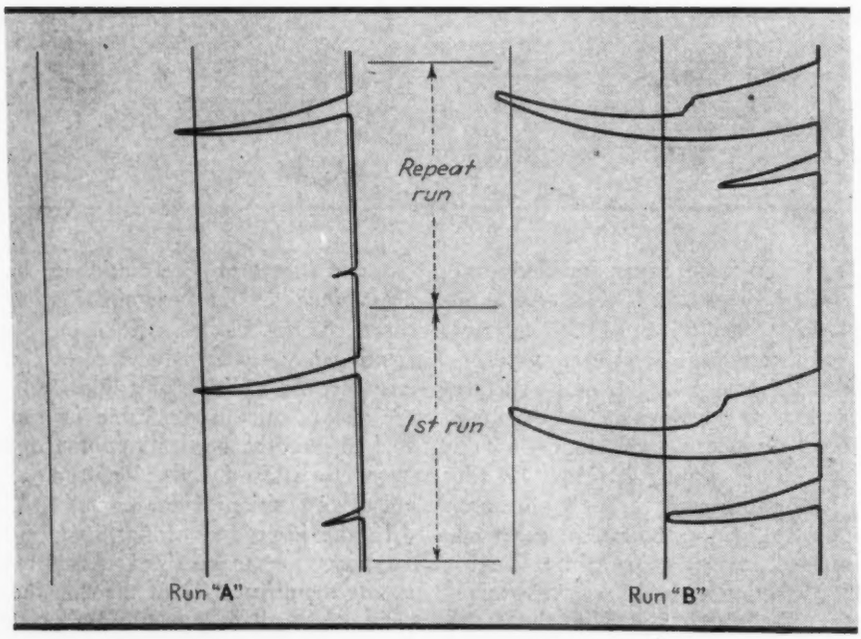


Fig. 6—Typical chart records of magnetically detected flaws.

Although the limitations of the magnetic flaw detector have not been determined, it appears to be a satisfactory method for the inspection of the interior surfaces of tubes. By calibrating the magnitude of deflection with the measured depth of flaws, it should be possible to use the instrument to measure the depth of flaws as well as their length.

Recent Developments in plastics and rubber

Almost two years of postwar experience have given engineers the opportunity to test the merits of plastics materials. Some of these materials have come through the postwar period with flying colors; a few have fallen by the wayside. In addition to reevaluation, the past two years have seen the development and application of new plastics materials, some of which were in the laboratory stage during the war. New production methods for plastics have also been developed; these are making application of new materials more feasible, and wider use of older plastics more economical.

In the following pages we present an editorial review of postwar developments in plastics — new materials, new processes, new applications—designed to give the engineer a broader working knowledge of this growing field.

POLYTETRAFLUOROETHYLENE

UNIQUE PROPERTIES: Chemical inertness, toughness over wide temperature range, resistance to high temperature, extremely low dielectric loss over a wide range of frequencies, resistance to all solvents, including high-boiling ketones, boiling sodium hydroxide, aqua regia, hydrofluoric acid and fuming nitric acid.

NEWEST INDUSTRIAL RESIN made available during 1946 was a polymer of tetrafluoroethylene, tradenamed "Teflon" by the Du Pont Company. First developed in 1943, this plastic was used during the war in gaskets, seals, and valve seats, where extremely corrosive conditions were encountered.

In sections thinner than 0.005 inch, Teflon is transparent, but in thicker sections it is opaque, with a waxy appearance and a color that varies from white to gray. No colored forms of the resin have been developed, but various inorganic fillers have been added to produce changes in properties.

Temperature Extremes

Teflon has no true melting point, but it undergoes a solid-phase transition from 608 to 621 deg. F. At these temperatures the coefficient of thermal expansion increases sharply. Even at room temperatures the coefficient of thermal expansion is twice as great as that of aluminum—this factor must always be considered in designing with Teflon. However, Teflon has been used in gaskets and wire insulation for jet engines, at temperatures up to 575 deg. F. It is also used in aircraft ignition systems near spark plugs where ordinary insulators fail at high temperatures.

Teflon's properties are equally good at low temperatures. Films of Teflon can be flexed without cracking at temperatures as low as minus 150 deg. F. The Izod impact at minus 70 deg. is 2.0 ft.-lb. per inch of notch, as compared to 4.0 ft.-lb. per inch at room temperature.

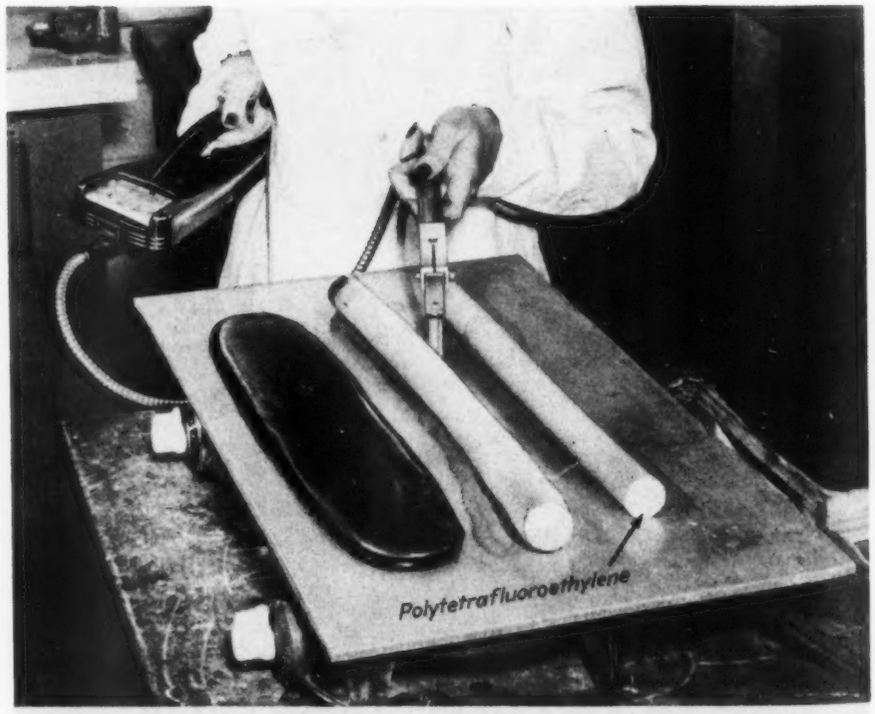
Solvent Resistance

Because of its extreme inertness, no cement has been found that will attack its surface sufficiently to make a good bond. This property can be used to advantage where a non-sticky surface is essential. Suggested uses are for containers to hold preforms in electronic heaters, for mandrels around which small coil-forms can be wound and cemented, for electronic fire-patching heaters, and for certain types of molds.

Water absorption of molded Teflon is very low and is rated zero by the standard A.S.T.M. test. This property, combined with its chemical inertness and high impact strength, makes it suitable for all types of gaskets, seals and valve seats.

Electrical Properties

The electrical properties of Teflon, coupled with heat stability, give it many potential applications in the power field, where one of the limiting features in the design of electrical equipment has been the lack of a suitable insulating material that will withstand high temperatures. Both the dielectric constant of 2.0 and the power factor of 0.02 percent are substanially constant over the full range of frequencies from 60 cycles to 3000 megacycles. The loss through the material is as low as, or even lower than, the loss in polystyrene or polyethylene, both of which are well



Polytetrafluoroethylene resin is claimed to retain its strength and form at higher temperatures than any other organic material. Above, on a plate heated to 390 deg. F., rod of "Teflon" is unaffected, while two other plastics have melted out of shape. *E. I. Du Pont De Nemours & Co.*

known for their electrical properties. Its surface and volume resistivity are both very high and its resistance to surface arc-over is excellent. Teflon softens and vaporizes rather than carbonizing to leave a conducting patch. Actual tests in circuit-breakers have proven that Teflon will last five or six times as long as other commonly used materials before it finally fails. Insulators and related parts made of Teflon are being used in the electrical industry. Thin tapes are being tested in electrical equipment as primary insulation and as material for slot liners.

Mechanical Properties

The tensile strength of Teflon runs from 2500 to 4000 lb. per sq. in. Like the more conventional thermoplastics Teflon is subject to cold flow, but this tendency is not excessive. In one test wire insulated with 0.080 inch of Teflon was looped over a 2¾ inch mandrel and maintained under a load of 50 lb. for 42 hours at 235 deg. C. X-ray photographs showed no measurable migration of the wire caused by flow of the plastic. More conventional plastic wire insulation would have been cut by the wire within a few hours.

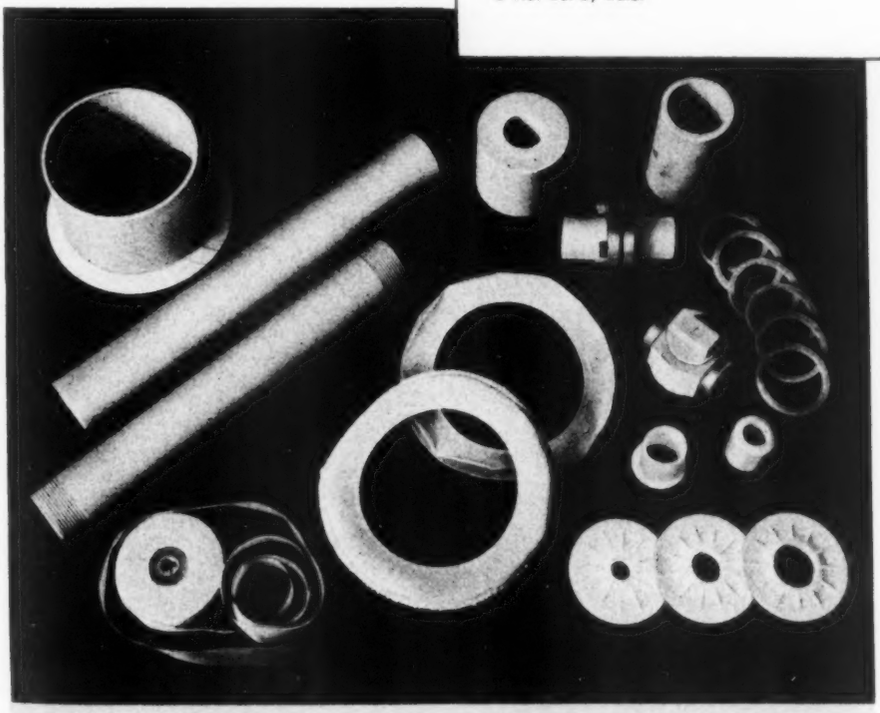
TYPICAL PROPERTIES OF TETRAFLUOROETHYLENE

(Data given represent standard commercial grades of material and standard methods of testing except where otherwise noted)

Property	Test Result	Test Method
Specific gravity	2.1-2.3	D792-44T
Tensile strength at 77 deg. F., lb. per sq. in.	2000-4500	D412-41T[1]
Elongation at 77 deg. F., percent	300-400	Die C[1]
Flexural strength at 77 deg. F., lb. per sq. in.	2000	D650-42T[2]
Stiffness at 77 deg. F., lb. per sq. in., (0.125 in.)	60,000	D747-43T
Impact strength, Izod, −70, 77, 170 deg. F., ft.-lb./in.	2.0, 4.0, 6.0	D256-41T
Hardness, "D," Durometer	55	.....
Compressive strength, lb. per sq. in. at 0.1 percent deformation	1700	D695-42T
Yield temperature, deg. F.	>320	Arl. M-8
Heat distortion temperature, low-load, deg. F.	266	D648 (B)-44T
Specific heat, cal. g. deg. C	0.25	.....[3]
Coefficient of expansion per deg. F. (77-140 deg. F.)	5.5×10^{-5}	D696-42T
Thermal conductivity, BTU/hr./ft.^{2}/deg. F./in. (0.18 in.)	1.7	Arl. P-32[4]
Brittleness temperature, deg. F.	<−100	D746-43T
Dielectric strength, short-time, volt/mil (0.080 in.)	480	D149-40T[5]
Volume resistivity, ohm-cm.	10^{16}	D257-38
Dielectric constant at 60, 10^3, 10^6, 10^8 cycles	2.0	D150-40T
Power factor at 60, 10^3, 10^6, 10^8 cycles	<0.0002	D150-40T
Water absorption, percent	0.00	D570-42[6]
Moisture permeability g./meter^2/24 hr.	0.00-0.5	D697-42T
Outdoor weathering	no detectable change in 1 year	

1 Tensile strength in oriented film may be as high as 15,000 lb. per sq. in.
2 Specimens do not break.
3 Method of mixtures.
4 Cenco-Fitch apparatus.
5 1000-2000 volt/mil in thicknesses 5 to 12 mils.
6 Not wet by water

E. I. Du Pont De Nemours & Co.



Applications of polytetrafluoroethylene include flared tubing, threaded pipe, cylinders, coaxial cable spacers, gaskets, tape, a plug cock, a valve-stem packing and a rod. Use is expected where resistance to heat and solvents, and high frequency insulation are required. *E. I. Du Pont De Nemours & Co.*

The solvent resistance and high softening point of Teflon makes fabrication of shapes quite difficult. Teflon can be extruded and is available in the form of rods and tubes. It can also be used as a wire coating by means of a screw stuffer of the conventional type. Sheets of Teflon, prepared by cold-pressing followed by baking, are available in thickness from 1/16 in. to 1¼ in. and are furnished in a maximum size of 24x24 in. Special shapes of simple cross-section can be formed by means of selected molding techniques.

At present the high cost of Teflon, approximately fifteen dollars per pound, and difficulties in fabrication have limited its applicability. Volume production is expected to bring the cost more nearly in line with other plastic materials and new techniques are being developed to reduce fabrication difficulties.

NEW MATERIALS

MODIFIED STYRENES

POLYSTYRENE BECAME AVAILABLE in much larger quantities in 1946. This happened concurrently with research to raise the heat distortion point of polystyrene plastics. These attempts led to the production of copolymers of styrene with divinyl benzene, styrene and acrylonitrile (in reverse proportion to that used in making one type of synthetic rubber), and polydichlorostyrene.

Monsanto's Cerex is one of the copolymers of styrene. Cerex X-207 has a heat distortion point of 203 deg. F. and can be immersed in boiling water for thirty minutes. Cerex X-214 has a heat distortion point of 230 deg. F. and can be immersed in boiling water indefinitely. Both resins darken on prolonged heating. Cerex requires higher molding pressures than polysterene; cost is somewhat higher. Other molding compositions of the modified styrenes are Dow's Styraloy, Rohm & Haas' Plexene M, and Mathieson Alkali Works' Polydichlorostyrene DCS.

General Electric's Textolite 1422, a cast modified styrene, is of special interest as a high frequency electrical insulator. High heat resistance and machinability to close tolerances are additional advantages. Textolite 1422 has an extremely low power factor with an A.S.T.M. distortion point of 105 to 113 deg. C. Since it can be cast, it can be used in many applications where compression or injection molded plastics are not suitable because of close tolerance requirements, necessary heat resistance and specialized electrical properties.

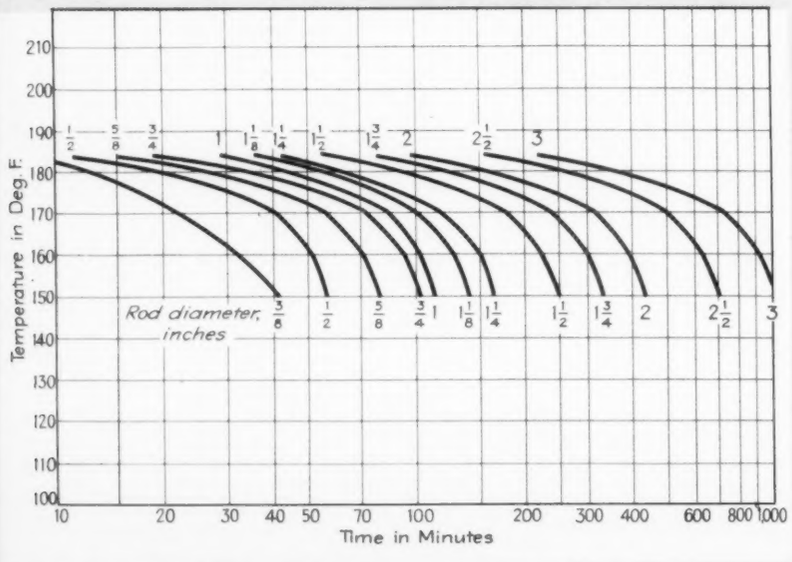
Dow's Styraloy has a high dielectric strength and a low power loss. It is flexible and shock resistant from minus 90 to plus 212 deg. F., is light in weight, and has negligible water absorption. Applications include handles for tools and numerous household appliances, gaskets, bushings, coilforms, scuff plates and belting.

Plexene M moldings do not show the marked tendency to crazing characteristic of many unmodified

PROPERTIES OF MODIFIED STYRENES

Property	Styraloy	Polydichlorostyrene "DCS"	Plexene M
Specific Gravity	0.05-0.97	1.39-1.40	1.08
Tensile Strength—lb. per sq. in.	900-1200	6,500-8,500	10,000
Flexural Strength—lb. per sq. in.	.....	7,500-15,000	16,000
Impact Strength, ft.-lb. per in. of notch, Izod	1.5-2.0	0.30-0.60	1.0
Rockwell Hardness	.....	M90-M100	M77
Reistance to Heat, deg. F., continuous	140-200	212-230	.....
Heat distortion, deg. F.	140-149	230-250	185-216
Dielectric Strength, volts per mil, short time	700	370	350
Dielectric Constant—60 cycles 10^6 cycles	2.4-2.5 2.4-2.5	2.64-2.66 2.64-2.66	3.0 3.0
Power Factor—60 cycles 10^6 cycles	0.0006-0.0008 0.0009-0.0015	0.0003-0.0008 0.0003-0.0008	0.007-0.013 0.007-0.013
Water Absorption, percent, after immersion 24 hr.	0.2-0.5	0.02-0.04	0.37*
Flammability, in. per min.	2.4	self-extinguishing	slow
Resistance to Strong Acids	good	good	good
Resistance to Strong Alkalis	good	good	good
Clarity	opaque	transparent	opaque
Color Possibilities	limited	unlimited	limited

*Immersion for 7 days



Annealing cycles for round polystyrene rods. *Plax Corporation*

ANNEALING OF

The availability of polystyrene explains the attention that has been given to the study of annealing it as a means of reducing internal stresses caused by molding to a point where the residual stresses can be borne safely without crazing or cracking. The Plax Corporation of Hartford, Conn., was probably the first to develop a simple means of finding the degree of residual strain. Its kerosene test consists of immersing a representative piece of the polystyrene material in kerosene for one minute at room temperature, then removing it without wiping and observing the result. If the piece is free from cracks at the end of thirty minutes after its removal from the kerosene, the annealing is satisfactory.

The Plax annealing process is done in a water bath which is kept circulating by a propeller and

styrene compounds. Laboratory tests indicate that maximum service temperatures of 90 deg. C. (194 deg. F.) should be satisfactory for Plexene M moldings, except where extreme dimensional stability is required. They show extremely low shrinkage, even for "heat resistant" thermoplastics and excellent resistance to weathering. Plexene M is practically unaffected by acids, alkali, and dilute alcohol. It is also resistant to gasoline and commercial inks but is attacked by organic solvents such as acetone and ethylene dichloride. Arc resistance of Plexene M is superior to styrene, but does show tracking after 140 ± 10 seconds. Its power factor is not as low as unmodified styrene. Preconditioning, such as drying for 7 days at 50 deg. C. (122 deg. F.) and immersing in water for 7 days have no appreciable effect on the electrical properties of Plexene M, except that water immersion does cause a slight increase in power factor at 1,000,000 cycles and slight loss of dielectric strength.

A new type of polydichlorostyrene has been developed by the Mathieson Alkali Works. Known as DCS, it is supplied as a molding powder. It has excellent resistance to high temperatures and can be left in boiling water indefinitely without softening or distortion. It is easily molded in standard injection molding machines, except that it requires slightly higher temperatures than ordinary polystyrene. DCS is odorless and has excellent resistance to strong acids and alkalis. Its dielectric constant and power factor are practically constant over a range of frequencies from 100 to 3x 10^9 cycles. DCS is available in semi-commercial quantities.

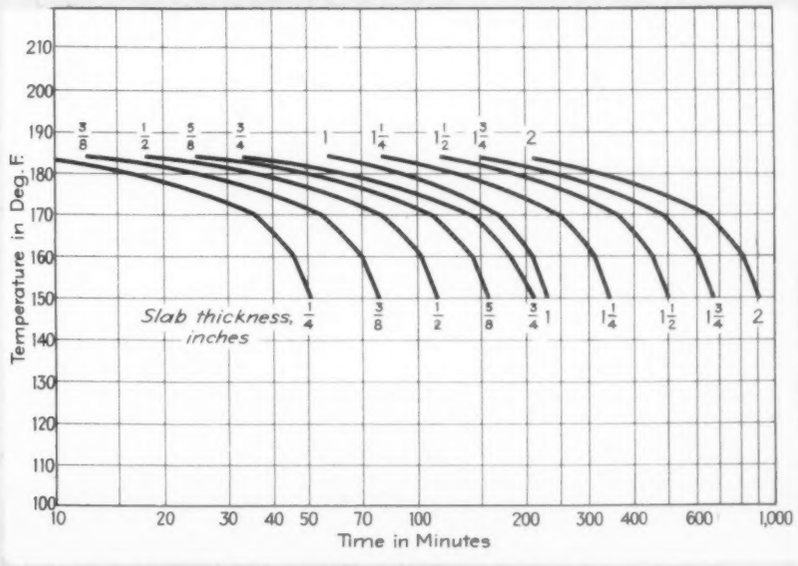
Typical Polyglas applications. (1) Waveguide windows; (2 a, b) beads for pickup probes; (2 c, d) pressurized coaxial connectors; (3 a, b) metal inserts; (3 c, d) same inserts molded into Polyglas male parts of high voltage connector; (3e, f) female portions of connector; (3g, h) new connector designs containing Polyglas molded inside; (4) Polyglas D⁺ sleeve, 1/32 in. thick, on beryllium-copper rod.

Polyglas

During the war mixtures of polystyrene and glass were developed to make a new series of "Polyglas" plastics. This research was carried out at the Laboratory for Insulation Research, Massachusetts Institute of Technology. Compositions which included silicone resins and polyvinyl carbazol, a mica-like plastic, produced materials with extremely high dielectric constants. Uses included a plate rod that served for the tuning of lighthouse tube cavities. In this application the Polyglas was molded as a thin sleeve on a beryllium-copper rod that was guided by tightly-fitting spring contacts. The plastic had to function at 100 deg. C. under this spring pressure without distortion, while matching the thermal expansion coefficient of the metal.

POLYSTYRENE

in which the temperature is controlled by an automatic cycle controller. Rods are kept in the bath until the end of the cycle, 150 deg. F., is reached. The time required varies theoretically as the square of the diameter or thickness. Machining strains in parts made from annealed stock are usually confined to a comparatively thin layer of material immediately adjacent to the machined surface. A simple heating cycle of only short duration is required to remove the strains in the surface layer. However, the primary source of deep body cracks are thermally induced cooling strains. Factors causing strains in polystyrene are its high coefficient of expansion (10 to 15 times that of steel), its low long-time strength, and its susceptibility to various liquid and vapor solvents. If these are particularly severe, modified styrenes can be used.



Annealing cycles for molded polystyrene slabs. *Plax Corporation*

THERMOPLASTIC MATERIAL

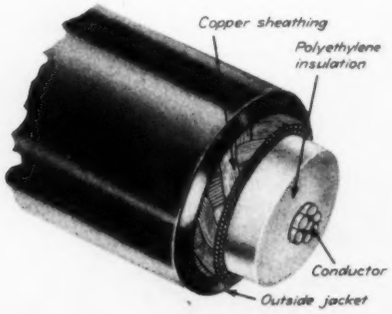
POLYETHYLENE

POLYETHYLENE WAS DEVELOPED during the war as a tough, flexible, low loss insulation for coaxial cable used in high frequency applications. Similar to polystyrene in chemical resistance, it is an opaque, semi-rigid plastic. In thin sections, it is extremely flexible but not rubbery or elastic. In thick sections it is rather stiff.

Polyethylene is one of the lightest and, from the standpoint of chemical structure, the simplest of the plastics now commercially available. It is a thermoplastic resin produced by polymerizing ethylene to form a simple long-chain hydrocarbon.

Developed by Bakelite and Du Pont, polyethylene has excellent water and low temperature resistance. It is resistant to most acids, including hydrofluoric acid. Its electrical properties are practically unaltered by water. The low heat distortion point of polyethylene and its low melting point (105 deg. C.) permit easy molding; these properties however limit its uses.

In addition to its use as an insulating material, polyethylene shows promise for moisture-proof packaging, shower curtains, and similar applications. Its resistance to weathering is good, although the material has a tendency to oxidize. Antioxidants are incorporated where maximum outdoor durability is required. With added lubricants polyethylene has found a large field in wiring coating; addition of polyethylene to butyl and GR-S synthetic rubbers for electrical use result in improvement in tensile strength, elongation, and electrical properties. Extruded sheeting, tubing, and belting are available in a variety of translucent and opaque colors.



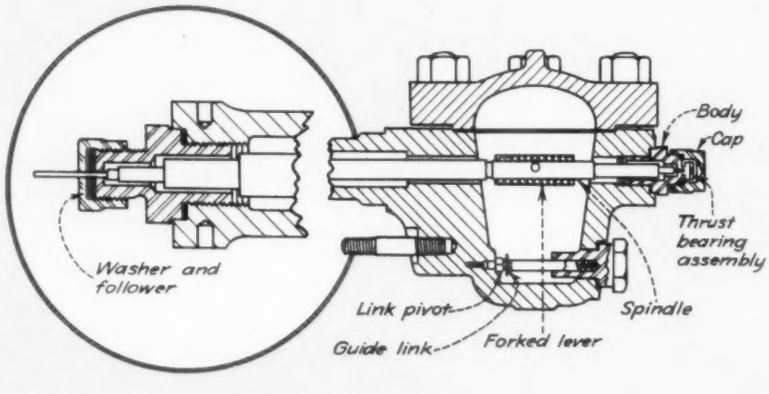
Unlike most insulating materials, polyethylene is not influenced by the oscillation cycles of a current. This non-polarity, coupled with low power loss at high frequencies, makes it useful as insulation on coaxial television cable.

PROPERTIES OF A STANDARD TYPE OF POLYETHYLENE

Properties	Test Results	Test Method
Specific gravity	0.92	
Stiffness: lb. per sq. in.		
25 deg. C.	18,000	ASTM D-747-43T
0 deg. C.	30,000	ASTM D-747-43T
−25 deg. C.	66,000	*
−50 deg. C.	160,000	*
Yield strength: lb. per sq. in.	1,475	ASTM D-412-41
Tensile strength: lb. per sq. in.	1,825	ASTM D-412-41
Ultimate elongation: percent	550	ASTM D-412-41
Brittle temp.: deg. C.	Below −70	ASTM D-746-44T
Tear strength: lb. per in.	500	ASTM D-624-41T
Abrasion volume loss (standard B rubber = 100)	55	**
Hardness: Durometer Type D	52-54	
Flammability	Slow burning	
Solubility	Insoluble in all common solvents at temperatures below 50-60 deg. C. Soluble in chlorinated solvents, aliphatic hydrocarbons, and aromatic hydrocarbons at elevated temperatures.	

*WC 72-B of Bakelite Corporation

**Test described by Duggan, F. W. "Abrasion Resistance of Flexible Vinyl Plastics." PRODUCT ENGINEERING, 14, 44-49 (January, 1943)



Replacing special rubber gasketing material and leather, this translucent disk of polyethylene, ⅜ in. in diameter and 0.050 in. thick, is used for a pressure-tight bearing washer on a line of fluid and steam meters. Advantages are low coefficient of friction, long service life, and relative ease of fabrication.

NEW APPLICATIONS

VINYL PLASTICS

UNIQUE PROPERTIES: Polyvinyl chloride, acetate and copolymers are characterized by thermal and light stability, toughness and chemical inertness.

THE VINYL PLASTICS were originally developed during research for rubber substitutes. It is no accident, then, that they are known as rubber-like plastics. The most common vinyl material is polyvinyl chloride. It is also produced as a copolymer with polyvinyl acetate; the latter compound is available as a seperate polymer. Other common vinyl materials include polyvinyl butyral and vinylidene chloride. Polyvinyl chloride is sometimes copolymerized with vinylidene chloride.

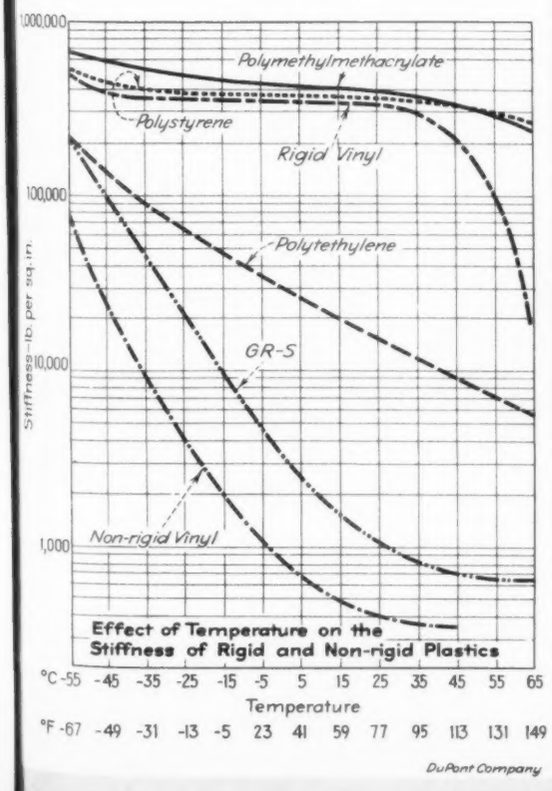
Vinyl polymers and copolymers are well-established in the electrical field, especially as wire and cable coverings. Other extruded vinyl products include tubing for corrosive chemicals, beverage tubing, gasket and packing material, garden hose, and automotive body and refrigerator strips. In different formulations the vinyls are being injection molded into such products as grommets for aircraft and motor vehicles, storage jars and cases, battery fuses, switch-boxes, light plugs, and ladles and buckets for chemical service.

Printing Plates

An interesting development to come out of the war is the vinyl plastic printing plate. A result of research for lightweight plates which could be airmailed all over the world, vinyl printing plates save time, reduce waste and lower costs. Instead of using wax to take the impression of the type form, vinyl plastic sheets are pressed against a reverse impression of the original type form by means of a heated platen in a hydraulic press. The advantage of using vinyl sheets are: (1) The mold can be used over and over for duplicates or to make new plates when the original is worn or damaged. The mold can also be stored without deterioration; (2) for accurate reproduction, a lead mold, which was formerly necessary, is not needed; (3) lower pressures are required, allowing use of lighter and less expensive equipment, and saving wear and tear on the type and engravings; (4) molds can be shipped without danger of damage, and with a saving in weight.

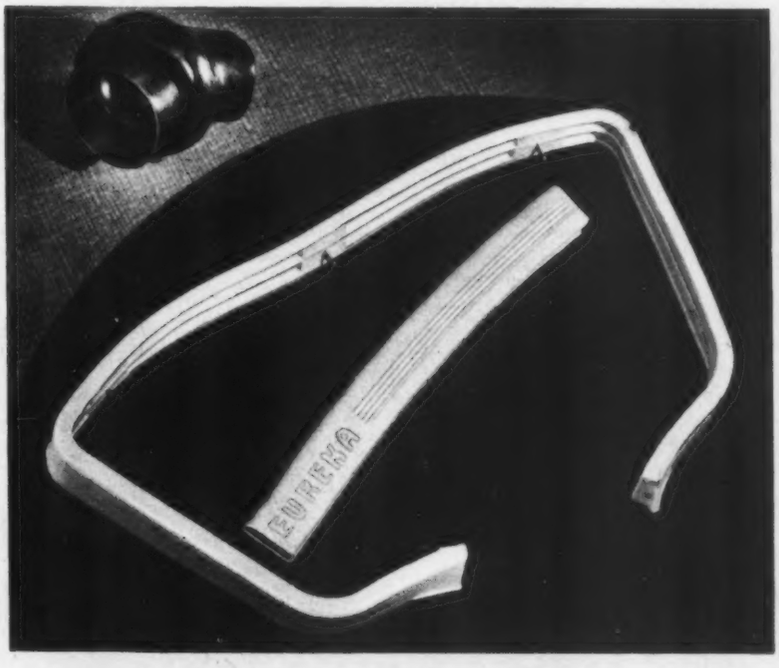
Molded Vinyl and Rigid Sheets

Vinyl plastics have been thought of as rather soft materials that are especially suitable for extrusion and wire covering. But these versatile materials have been made in many other forms. Without any plasticizers or lubricants added, vinyls can be produced as rigid transparent sheets. As such they are especially suitable as attractive and corrosion resistant boxes for industrial and consumer products. These boxes can be fabricated in a variety of shapes and sizes. More significant, perhaps, is the development of molded vinyl products. For this purpose an "elastomeric" formulation, in which selected plas-



Effect of Temperature on the Stiffness of Rigid and Non-rigid Plastics

DuPont Company



Three parts of the Eureka vacuum cleaner which are molded from vinyl elastomeric plastics. Below, the bumper and bag grip are extruded in smooth ivory. At the top, the dust brush holder is molded in maroon to match the ensemble of the cleaner. Bakelite Corporation

FABRICS AND FILMS

The application of vinyl chlorides, acetates and butyrals to fabric coating is widespread. Common methods of application include calendering, solution coating, knife spreading, transfer coating, film casting, and tower coating. The result is a product of varying thickness and strength, which is resistant to water and many solvents.

A recent development in this field are the "organosols" which are powdered vinyl resins suspended in an organic liquid, a non-solvent or diluent. A paste is obtained, which can be spread-coated on cloth, dip-coated on forms, or squirted under low pressure into molds. Moderate heating will fuse the dispersions into a homogenous film or casting which is tough and elastic. Pigments can be incorporated if color is desired. Related are the "plastisols," in which the vinyls are suspended in a plasticizer, such as Socony-Vacuum's Sovaloid C. These are used to make solid vinyl "castings."

Organosols can be applied in almost any film thickness on the simplest coating equipment in almost all textile-converting plants. Unlike orthodox methods, the viscous solution is applied to a fabric and the solvent is then driven off with an extensive drying system. Four advantages are claimed for the plastisol method: (1) Expensive equipment is not needed; (2) inflammable solvents are not used; (3) control of finished dimensions is easier; (4) conversion from fluid to solid state can be done continuously at high speeds.

Polyvinyl Butyral

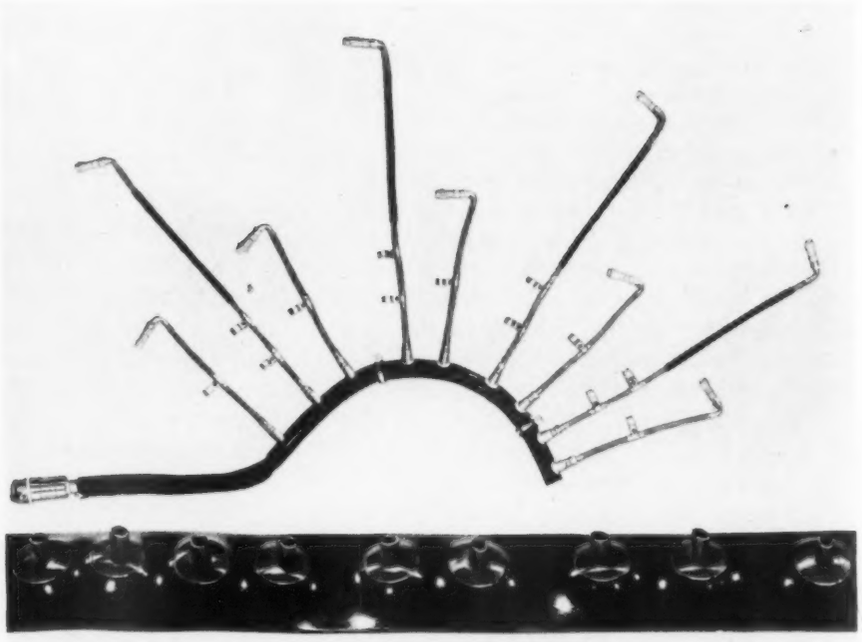
Polyvinyl butyral was developed about fifteen years ago to serve as the interlayer of automotive safety glass. Today, although it still finds a large market in this application, polyvinyl butyral is also serving in the fields of textiles, paper, metal foils, leather coatings, general "elastomeric" or rubber-like applications, and adhesives. When used as a coating material, it can be handled on any type of coating machinery. For coating paper or foils, solutions can be applied by knife or roll-coaters. Polyvinyl butyral makes an excellent waterproof and greaseproof packaging material. An interesting property of this material is its ability to disperse in water, to form a latex of excellent stability. Films can be cast from this latex at room temperature without any additional heat except that required to remove the water.

Properties of Polyvinyl Butyral Film

Specific Gravity	1.077
Tensile Strength (ASTM D 412), lb. per sq. in.	1650
Elongation at break, percent	300
Shore Hardness	40
Brittle Point (ASTM D 746), deg. C.	−49
Modulus of Rigidity lb. per sq. in.	
25 deg. C.	250
−20 deg. C	37,000
Heat Resistance (24 hr. at 25 deg. C.), percent	4.7
Weathering, hr.	
Twin Arc Weatherometer	200*
Sun Lamp	140†
Florida Sun Exposure (2 months)	180

*Negligible change †Slight yellowing

Monsanto Chemical Company



Above, one of two manifolds which make up an aircraft ignition harness. An extruded vinyl plastic sheet is molded over the manifold assembly by pressure and electronic heating. Outlets on designated positions on the vinyl sheet, below, are electrically molded into an integral part of the jacket. *Bakelite Corp.*

ticizers and fillers have been incorporated, is used. Rubber-like products can thus be injection molded of vinyl materials. Several examples of such products have been marketed recently: (1) An accelerator pedal has been injection molded around an iron core by the Hungerford Plastics Corporation where oil resistance of the vinyl pedal has proved far superior to materials formerly used. In addition rapid production has been implemented by the use of injection molding. (2) The brush holder of the Eureka vacuum cleaner has been molded of a vinyl elastomeric formulation, which was fairly rigid. This piece has a thin section measuring 0.068 in., while the heavier sections grade up to 0.475 in. Extruded vinyl bumper and bag grips are also used in this product.

Vinyl plastics can be compression molded to any degree of hardness. Molding is done preferably with preforms. Transfer molding, in which the molding compound is ejected from a preheating chamber into the mold proper at the desired plasticity, is perhaps the best type of compression molding for vinyls. This method obviates the problem of "weld" losses, and a minimum of excess stock is used.

Aircraft Ignition Harness

Three types of vinyl products have been combined to make a product of considerable importance to the electrical industry. This is an aircraft ignition harness (shown in accompanying illustration) used in large transport planes. First, calendered vinyl tape, 0.008 in. thick, is wound around a fluted synthetic rubber core, through which one wire passes and on which 8 manifold wires rest. This is covered with brass foil. Then, extruded vinyl sheet 0.125 in. thick, provided with vinyl outlets or "nipples" molded on electronically, is wrapped lengthwise around the assembly, and sealed by electronic heating. Extruded vinyl tubes, with metal fittings at both ends, are then attached to the outlets. 5 mm. wiring is then forced through the tubing by carbondioxide pressure. Two layers of copper shielding are then braided around the tubing to prevent radio interference.

In transporting current from magnets to spark plugs, constant precision operation is assured. Advantages claimed are resistance to deicing fluid, high dielectric strength, stability under high and low temperatures, little loss of time to repair and replace harness.

NEW APPLICATIONS

PROTECTIVE COATINGS

THE SURFACE COATINGS INDUSTRY continues to take more of the synthetic resin output than any other group. Practically every type of plastic is used at one time or another for this purpose. Notable advances in this field include:

VINYL PROTECTIVE COATINGS. Perhaps the single development born of war research that can be used in postwar industry with practically no modifications is the "spray packaging" process developed by the U. S. Navy. This process can be used for packaging and storing indefinitely equipment of all types, in sizes ranging from a tiny screw up to and including a battleship. The packaging process begins with a framework of pressure-sensitive tape built up around the object to be sealed. The spraying operation then applied to this framework consists of four steps: (1) A vinyl-base webbing solution is applied from a standard spray gun. Filaments of vinyl material are extruded and form a cobweb-like structure over the surface; (2) a "moisture barrier coating" is then sprayed on. This is a solution of vinyl resins from which the webbing agent has been omitted. This coating is built up by continuous spraying to the desired film thickness; (3) a pigmented vinyl-base top coat is applied, if long-term outdoor storage is to be encountered; (4) before the coating is completed, a dessicant is added and a transparent plastic window is inserted. Thus, dangerous moisture content can be observed on a colored indicator through the window.

Vinyl caps and sleeves, used to protect copper tubes in refrigerator units during manufacturing operations, are supplied by the General Electric Company.

A postwar version of this process has been developed by the R. M. Hollingshead Corporation of Camden, N. J. For extreme outdoor conditions the Hollingshead process, known as "Cocoon," includes top coatings of an asphalt-base material and an aluminum solution. These coatings are easily strippable, and, in addition to their use for storage, indications are that they will be extremely valuable in shipping manufactured products to extremely damp and hot climates, where corrosion and fungus growth prevail. Resins for these vinyl coatings are supplied by the Carbide and Carbon Chemicals Corporation, under the "Vinylite" tradename, and by the United States Rubber Company under the name of "Kotol." The latter product has a tensile strength of 900 lb. per sq. in., low moisture vapor transmission, and good elongation and toughness. A dip version of these vinyl coating methods has been introduced under the name of "Seal-Peel." It can be applied at low temperature and is especially useful in the small fabricating shop, where elaborate equipment is not available.

Protection During Fabrication

An important use for vinyl strippable coatings, in addition to packaging for storage and shipping, is to protect parts during fabrication and other production processes. A special tape, made of extruded vinyl plastic has been marketed by Michigan Chrome and Chemical Company under the name of "Miccrotape," specifically for the purpose of masking off surfaces during electroplating. An important use for this tape is in masking parts for hard chrome plating or selective copper plating prior to carburizing, since it fits snugly in grooves and round shoulders. After plating the tape is quickly removed, leaving a perfectly clean, unmarred surface.

For storage or shipping, machine is packaged by spraying on vinyl plastic "webbing" and top coat.

Carrying this idea one step further, vinyl "caps and sleeves" are being produced by the General Electric plastics division. Processing includes a special dilator solution supplied by G. E., in which the caps, sleeves or tubing is immersed for a period of two to four hours. This expands the material, which is then draped over the part to be protected during processing. The vinyl material soon shrinks to form a tight fit around the product. It is easily removed by cutting with a knife. Another use for this material is as an insulating covering on pliers and wire cutters. Tests indicate that it is resistant to heat in industrial baking cycles.

Vinylidene Chloride

Strippable and other types of protective coatings are produced from copolymers of vinylidene chloride, tradenamed "Saran" by the Dow Chemical Company. Coatings based on these resins have a high degree of resistance to solvents, greases, acids and alkalis. Applications include packaging, lacquer, corrosion-resistant paint, artificial leather, electroplating, adhesives and textiles. Copolymers of vinylidene chloride and acrylonitrile synthetic rubber are marketed as Saran F-120, while vinylidene chloride latex for spray packaging and other coating applications, is available as Saran F-122.

CELLULOSIC COATINGS. A cellulose acetate butyrate gel lacquer for dip coating. Developed by the Tennessee Eastman Corporation, the first application of the new gel lacquer was as a coating for airplane control wheels, which are lightweight aluminum castings. The plastic is applied simply by dipping. The gel lacquers are made by dissolving cellulose acetate butyrate pellets of the desired color in suitable solvents. Upon drying the lacquer sets in a hard continuous surface coating which has a natural high gloss. Protective strip coatings of cellulose acetate butyrate are also applied from a solution in hot castor oil, in which a small amount of rust-preventive oil has been added. This method is especially useful when a tough coating for protection of parts against corrosion and abrasion during transit and storage is required. These coatings, after being stripped, can be melted and reused. At the Bell aircraft plant in Buffalo, this plastic dip is being applied to carbide-tipped tools to protect them against chipping and abrasion while in the storage crib or in transport.

Cast aluminum airplane control wheels are dipped in Tennessee Eastman cellulose acetate butyrate "Gel Lacquer," to make a smooth, chipproof finish.

SILICONE COATINGS. Silicone paint provided a new wrinkle in field of "plastic paints." Still in the development stage at General Electric, tests show that this product is highly resistant to severe weather conditions, chemicals and heat. Applications in which silicone paint shows promise are finishes for automobiles, refrigerators, electric ranges and hospital equipment. It is felt that silicone paint in these applications would be resistant to discoloration caused by hot grease, fruit juices, and iodine.

Properties of Saran F-120 Resin	
Specific Gravity	1.60
Area Factor, sq. in. per lb.	17,3000
Refractive Index at 25 deg. C.	1.580
Tensile Strength, lb. per sq. in.	8-10,000
Elongation, percent	8
Moisture vapor transmission of 1 mil film, g./100 sq. in./24 hr.	0.15

Properties of Plasticized Saran F-122 Latex Film*	
Area Factor (sq. in./lb./mil.)	18,500
Density (25 deg. C.)	1.50
Tensile Strength (lb. per sq. in.)	2,800
Percent Elongation	220
Elmendorf Tear (grams)	850
Fold Endurance (cycles)	176,000

*20 percent Dibutyl Phthalate Plasticizer

CASTING SEALANTS

For anti-corrosion and pore-sealing treatments of metal castings, plastics are receiving wider use. Specially modified phenolics and polyester resins are being employed for protection and salvaging of all types of porous castings. Four types of phenolic coatings are used; these can be applied by spraying, laminating, extruding onto interior surfaces, or by impregnating.

Polyester resins, some of which are used in the new "low pressure" plastics, are receiving wide use in sealing porous castings. Based on the "Laminac" resins of American Cyanamid Company and the "Thalid X-100" resin series of Monsanto Chemical Company, a pressure-sealing method, has been developed by Polyplastex, Inc., of Woodside, L. I. Polyplastex MC is resistant to all solvents, petroleum products, water, and to temperatures up to 350 deg. F. A different formulation, Polyplastex Hitemp, is stable to temperatures up to 2000 deg. F. By this method, leaking castings can be salvaged economically with a saving of machine labor that has been put into them.

Lightweight radar, ordnance and aircraft castings are salvaged after impregnation with "Polyplastex MC" casting sealant.

Three general methods are used in the pressure-sealing process: (1) Vacuum-Pressure. Castings are set in a chamber evacuated to a pressure of not less than 27 in. of mercury. The sealant is brought in under vacuum, and floods the chamber. Vacuum is released and air pressure applied. (2) Internal-Pressure. All openings in the casting, but one, are plugged. Impregnating solution is poured in the orifice, and air pressure applied. (3) External Pressure. All holes are closed and a vacuum line attached to one of the closures. Entire casting is submerged in the sealant and a vacuum is applied, pulling the material through the side walls.

Stable finish is obtained by curing at 250 deg. F. in infra-red or steam ovens.

PLASTICS-SYNTHETIC RUBBER COMBINATIONS

NEW MATERIALS

THE TREND toward attainment of desired properties in plastics by copolymerization is reaching over into the synthetic rubber field. Mixtures of phenolic or vinyl resins and synthetic rubbers are being used to impart greater toughness to molded products or to speed up cure and improve the chemical and heat resistance of rubber stocks.

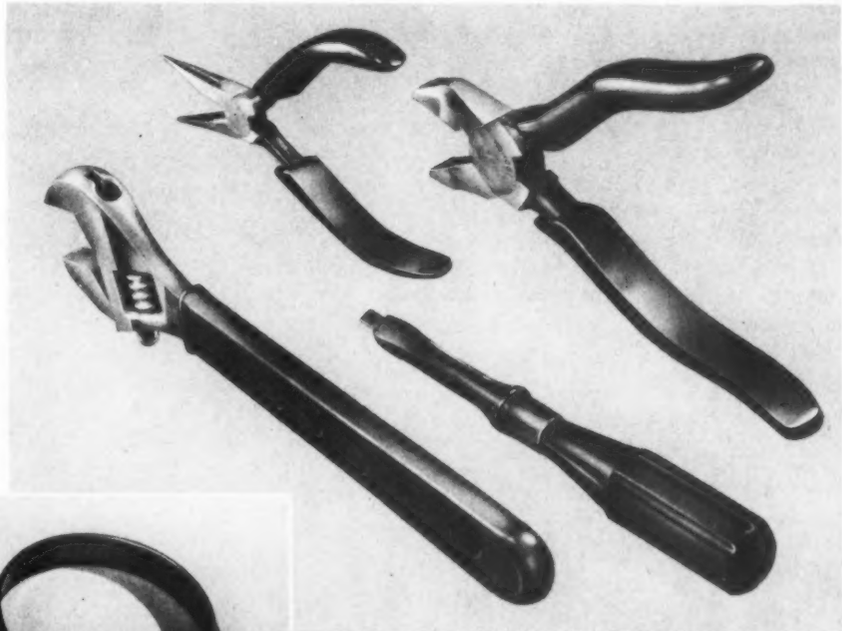
Three types of plastics-rubber blends have been developed by the B. F. Goodrich Chemical Company. The first is a combination of polyvinyl chloride with butadiene-acrylonitrile synthetic rubber (also known as Buna N or "nitrile"). Some of the improved properties of the new products are: (1) Increased flex life; (2) sunlight and ozone resistance. When 25 percent or more vinyl chloride in incorporated, there is a remarkable increase in resistance to sunlight and ozone; (3) reduced flamability; (4) reduced creeping in lightly loaded stocks; (5) improved abrasion resistance.

Plasticizing Rubber

Addition of the vinyl plastic to rubber also makes possible reduction in amount of plasticizer added; some of these have extremely objectionable properties. This also results in improved resistance to oils. Another advantage is that it opens the possibility of higher loading, resulting in lower cost compounds. Physical properties such as elongation, compression set, cold flow characteristics, resiliency and low temperature flex life were all improved. For example, such blends can be used at temperatures about 25 deg. C. lower than conventional vinyl plastics. Another important property which synthetic rubber imparts to the vinyl compound is the ability to pull it from a hot mold without tearing. Thus, it is now economically possible to compression mold *thermoplastic* products from polyvinyls by eliminating the necessity of cooling the molds.

A second development showing promise in this field is a three way combination of butadiene-acrylonitrile rubber, polyvinyl chloride and phenolic resins. Depending on the percentage of each ingredient, compounds derived from this three way blend vary from a soft elastomeric to a hard, tough compound. The value of these compositions lies in the fact that hard rubber-like products can be prepared without recourse to high sulfur contents and the defects resulting from such compounding. Impact resistance of these materials is outstanding. These hard products are light in weight and reproduce mold surfaces so faithfully that no finishing is necessary. Electrical properties are also improved. Examples of products made from this material are: (1) Propeller deicer rings; (2) industrial screw driver handle; (3) ice bucket.

Third, phenolic resins alone added to Buna N synthetic rubber result in sulfur-free products of excellent abrasion resistance. When 25 to 30 percent phenolic is added, the product resembles vulcanized rubber and has a tensile strength from 1500 to



Insulated tools made from vinyl chloride and nitrile by the Connecticut Hard Rubber Company. Pliers are tested to 20,000 volts.

Ice bucket, propeller de-icer ring, gasoline hose, screw driver are made from polyvinyl chloride, nitrile rubber and phenolic resins.

B. F. Goodrich Chemical Company

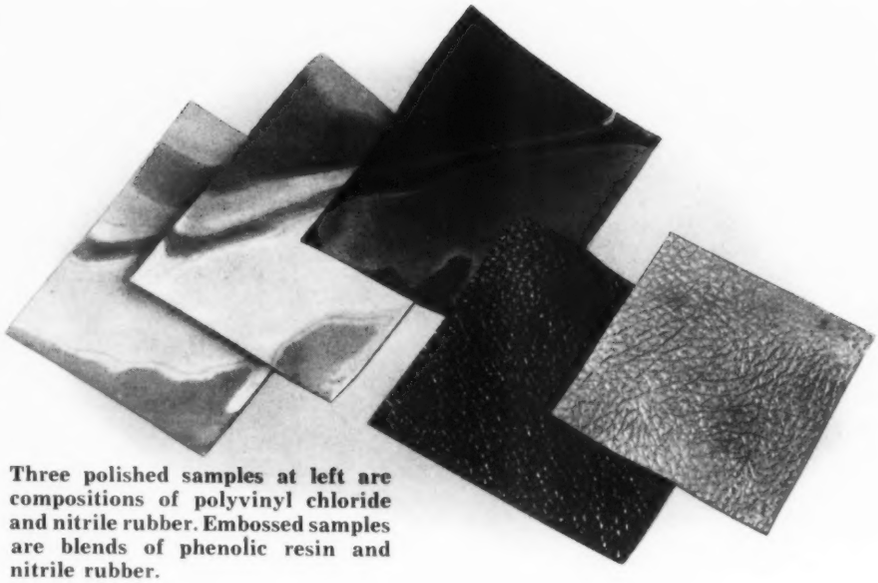
3000 lb. per sq. in., and elongations of 100 to 450 percent. When excess phenolic is added, the compound can be handled like ordinary plastics; impact strength is improved while tensile strength falls off.

Plasticizing Vinyls

Nitrile synthetic rubber, when blended with vinyl chloride, vinyl acetate and copolymers, acts like a plasticizer, and improves physical properties. Studies made by Enjay Company, Inc. and the Standard Oil Development Company show that addition of nitrile: (1) Decreases the amount of ester-type plasticizers necessary to obtain equivalent or better properties; (2) reduces "bleeding" of such plasticizers; (3) improves elongation; (4) improves low temperature properties as evaluated by brittle tests; (5) improves set and coldflow properties.

Impregnated Fabrics

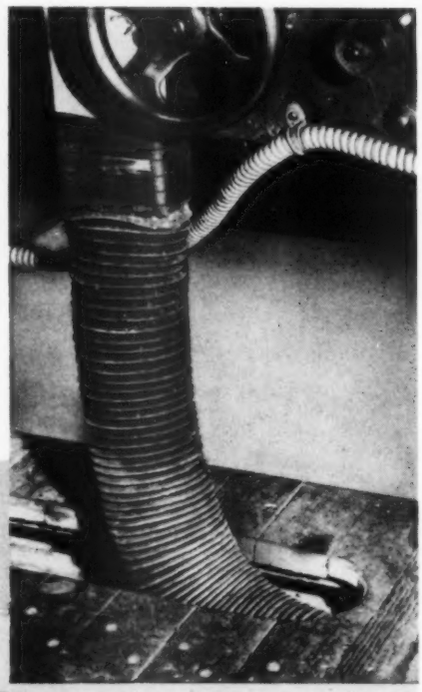
These synthetic rubber-plastic combinations are also being used by the U. S. Rubber Company to impregnate glass and asbestos fabrics for special purposes. Products made from such fabrics include ducts for heating and ventilating, and for carrying flour, sugar and chemicals in manufacturing plants, dust excludes boots for protecting machine parts against dust and abrasives, and bellows for such devices as resuscitators and enlarging cameras. These synthetic rubber - plastic combinations are also being used to produce adhesives of outstanding quality; this is especially true of the phenolic-rubber compounds.



Three polished samples at left are compositions of polyvinyl chloride and nitrile rubber. Embossed samples are blends of phenolic resin and nitrile rubber.

Other resins compatible with synthetic rubber are the alkyds, some of which are useful as heat-resisting plasticizers. Polyethylene has been used as a processing aid with GR-S, or the styrene type of synthetic rubber. Polyvinyl butyral, which "handles" like rubber and has many similar applications, can be combined directly with GR-S; here, it serves to reduce shrinkage tendencies.

Thermoplastic rubber-plastics copolymers have been "tailor made" for use as chemical-resistant paints and paper coatings. Finishes obtained are scrub-resistant, and resistant to heat and most solvents, including strong acids and alkalis. A concrete panel painted on one side with an enamel prepared from one of these compositions was submerged in water for several weeks, with no ill effects. Oleoresinous concrete enamels subjected to the same test blistered over night because of the reaction between the alkali in the concrete and the paint vehicle. The Goodyear Tire and Rubber Company has developed such products under the names of "Pliolite S-5" for paints and "Pliolite S-7" for paper coating.



Ducts for aircraft and for carrying dust and abrasives are made from glass cloth or asbestos impregnated with a blend of neoprene or GR-S with phenolic resins.

PROPERTIES OF "PLIOLITE S-5"

Specific gravity	1.03
Softening Point, deg. C.	50
Tensile Strength, lb. per sq. in.	1450
Elongation, percent	0.0
Iodine Number	57.8
Acid Value	Neutral
Color—Resin Powder	White
Milled Resin	Light amber
Solution	Very pale amber
Film	Clear and colorless
Index of Refraction	1.585
Solution Vicosity . . .	Can be varied to meet requirements

Goodyear Tire & Rubber Co.

SYNTHETIC RUBBER

SUBSTANTIAL IMPROVEMENTS have been made in the quality of synthetic rubber; the quality differential between GR-S and natural rubber has become a matter of considerable debate. Because of government release of natural rubber for tire manufacture during 1946, the importance of this differential became greater. When GR-S was first utilized, recognizable processing difficulties were experienced and there were many complaints from fabricators because of lack of uniformity. These difficulties have been largely eliminated, and at present GR-S can be processed in a majority of fabricating operations at approximately the same cost as natural rubber.

It is generally recognized in the rubber industry that a passenger car tire produced from substantially 100 percent GR-S now gives performance approximately equal to an average prewar natural rubber tire, and in many cases the GR-S passenger car tires are giving superior performance. Substantial progress has been made toward improving the service characteristics of truck tires containing large percentages of GR-S and it is not unreasonable to expect extensive future use of synthetic rubber in their manufacture.

GR-S – More than a dozen different types of GR-S are in regular production and more than 250 types have been produced in plant scale equipment. Among those of special interest is a polymer made from isoprene alone instead of from butadiene and styrene, having chemical properties closely resembling those of natural rubber. Another type in which isoprene and styrene are copolymerized shows promising properties for use in tire carcasses. It has been found that if synthetic rubber latex is coagulated with acid alone the product possesses valuable properties for wire and cable insulation. Certain types of GR-S have been produced with non-staining antioxidants for uses in which discoloration of rubber is objectionable.

One of the more important advances in GR-S manufacture has been the production of a butadiene-styrene copolymer emulsified with rosin soap. This copolymer shows markedly increased tack and uniformity and offers promise of longer tire life than the standard inclusion

TYPES OF SYNTHETIC RUBBER

Synthetic rubbers can be divided into two classes, the general purpose rubber, GR-S, and the specialty rubbers, Neoprene, Butyl, Buna N and Thiokol.

GR-S is the American modification of the German Buna S. GR-S means Government Rubber, Styrene type. It is a copolymer of butadiene and styrene. It replaces natural rubber in many applications, including tires, and the United States has a plant capacity to produce nearly a million long tons annually.

NEOPRENE was developed by the E. I. du Pont de Nemours & Co. and introduced commercially in 1932. It is a polymer of monochlorbutadiene known as chloroprene, made from acetylene. When produced in government owned plants neoprene is designated GR-M, (Government Rubber, Monochlorbutadiene). It is produced in this country at the rate of 60,000 tons per year. Neoprene is superior in products which come in contact with oil and neoprene latex is a good substitute for natural rubber latex in a number of applications.

BUTYL rubber was developed in this country during the war by Standard Oil Development Company. It is a copolymer of isobutylene and isoprene (predominantly isobutylene) and when produced in government owned plants is designated as GR-I (Government Rubber Isobutylene). Production of butyl is around 100,000 long tons annually. Butyl has great air tightness and is preferred to natural rubber for inner tubes.

BUNA N or "nitrile" rubber is a copolymer of butadiene and acrylonitrile (containing from 15 to 40 percent of the latter). When produced in government owned plants it is designated GR-A, (Government Rubber, Acrylonitrile). It is also known under the trade names of Butaprene, Chemigum, Hycar, and Perbunan. Nitrile is important for oil resistance.

THIOKOL is the trade-name of the Thiokol Corporation for alkylene polysulfide. Discovered in 1920, it was first produced commercially in 1930. Molding characteristics and resistance to water, oil and solvents are excellent. Its government designation is GR-P.

COMPARATIVE PROPERTIES OF COMMERCIAL SYNTHETIC RUBBERS

	Natural Rubber	GR-S	Buna N	Neoprene	Butyl
Physical Properties					
Extensibility	Excellent	Good	Good	Excellent	Excellent
Resilience	Excellent	Good	Fair–Good	Very Good	Low
Tensile	Excellent	Fair–Good	Good	Very Good	Good
Electrical Properties	Excellent	Excellent	Fair	Fair	Excellent
Impermeability to Gases	Good	Good	Good	Very Good	Excellent
Impermeability to Water	Good–Very Good	Fair–Good	Fair–Good	Fair–Good	Very Good
Resistance to:					
Plastic Flow	Very Good	Good	Good	Good	Fair–Good
Abrasion	Very Good	Good–Very Good	Good–Very Good	Very Good	Fair
Tear	Very Good	Fair–Good	Fair–Good	Good	Fair–Very Good
Heat	Good	Fair–Very Good	Fair–Very Good	Very Good	Fair
Cold	Very Good	Very Good	Fair–Good	Fair–Very Good	Fair
Chemical Properties					
Resistance to:					
Air	Fair	Good	Good	Excellent	Excellent
Ozone	Inadequate	Inadequate	Fair	Excellent	Excellent
Light	Fair	Fair	Low	Excellent	Excellent
Petroleum	Low	Low	Excellent	Good	Low
Aromatic Oils	Inadequate	Inadequate	Fair	Low	Inadequate

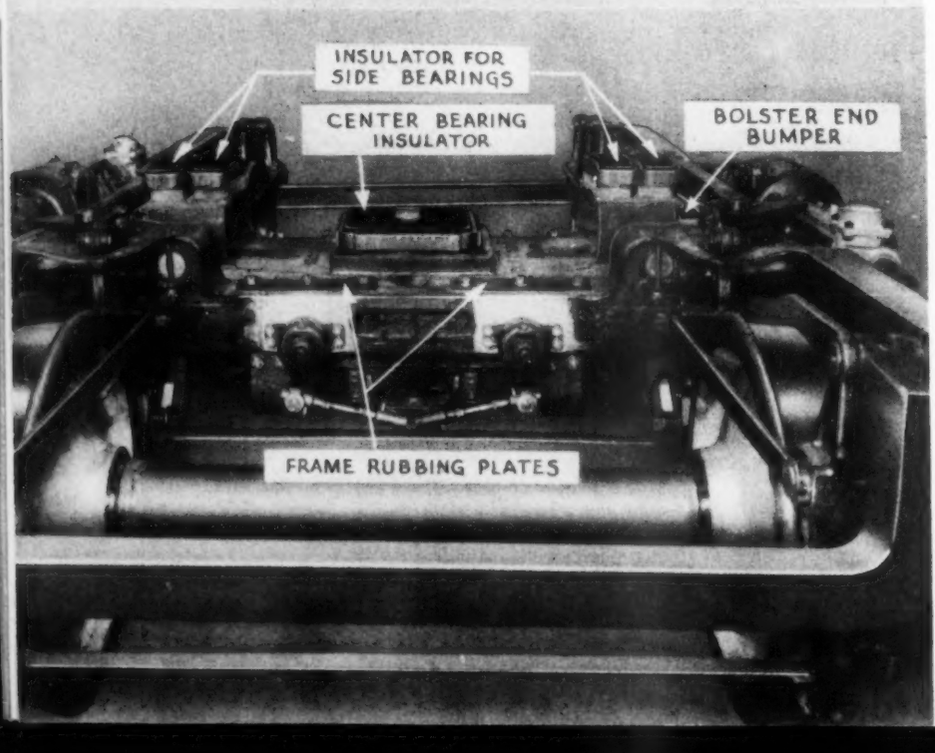
U. S. Rubber Co.

of carbon black in the rubber prior to coagulation of the latex. This adaptation has solved several processing problems in the rubber products manufacturing industry, particularly in smaller companies which do not have sufficient milling equipment to incorporate the black with the finished rubber.

A white reinforcing material which functions in the same manner as carbon black has recently been developed. This material improves physical properties, and will permit production of rubber products in light colors. Research on vulcanizing agents has revealed an entirely new class of nonsulfur halogen compounds which are expected to improve the properties of GR-S.

In the manufacture of rubber products other than tires, the particular qualities of the type of rubber used are often of a significance equal to or greater than the cost of the rubber. Since synthetic rubbers are chemical materials, it is possible to produce a number of special types with specific properties for particular applications. Present technological improvements have brought GR-S to a point where the choice between it and natural rubber in many cases is solely a matter of cost.

A truck for high-speed railway passenger cars, equipped with rubber mountings designed by United States Rubber Company to absorb noise and vibration.



BUTYL – The use of butyl rubber for applications in which air retention properties are important has continued to increase. Inner tubes produced from butyl are generally considered to be superior to those produced from natural rubber because of their greater resistance to tear and an extremely low rate of air leakage, approximately 10 percent of that of natural rubber.

Butyl is different from the other synthetic rubbers in both chemical and physical properties. The tensile properties of butyl are good. It has very high stretch. Abrasion resistance is fair to good, depending upon the application. It is particularly good for high temperature steam applications. The outstanding advantages of butyl are its chemical resistance and its low permeability to gases. Because of its chemical resistance, butyl is used to good advan-

tage in tank and pipe lining, but unlike neoprene and Buna N, it is not resistant to oil and gasoline.

It differs from rubber and from the other synthetics in its processing requirements. One of its disadvantages is that it requires a longer curing time. Butyl may be plasticized by milling with plasticizers, vulcanized with sulfur and rubber chemicals of the ultra-accelerator type, but cannot be vulcanized to hard rubber.

NEOPRENE – Neoprene has a number of valuable properties not possessed to the same degree by natural rubber. The most striking of these are oil resistance, resistance to cracking when exposed to sunlight or ozone, and failure to support combustion. Neoprene has reasonable good strength and abrasion resistance. One limitation is its tendency to harden as the temperature is lowered. This property has been largely corrected in one type of neoprene known as neoprene "FR." Neoprene is appreciably heavier than natural rubber.

Neoprene requires the addition of carbon black to bring out its best properties. It is much poorer than natural rubber in light colored and pure gum stocks but better than GR-S. It cannot be cured to hard rubber. Neoprene in latex is becoming increasingly important to industry. One of its advantages in rubber thread is that it resists dry cleaning. It is the best synthetic rubber latex available for dipped goods and other applications where physical properties are important.

In solid form neoprene is preferred to natural rubber in mechanical goods exposed to gas and oils such as gasoline hose, and in products which come in contact with fats and grease as in milking machine parts, and aprons and boots in dairies and garages. Neoprene tires are being fabricated by the Automatic Transportation Company, Chicago, for the drive wheels of its motorized hand trucks.

NITRILE – All of the Buna N or nitrile types are fairly similar to one another in their properties. Their chief advantage is that they are resistant to oil and gasoline.

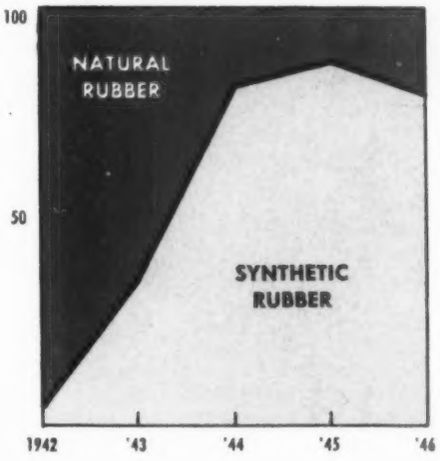
When specially compounded, nitrile does not stiffen up at low temperatures. Its resistance to sunlight and ozone is not as good as neoprene. As in the other synthetic rubbers, it is necessary to use a fairly large amount of carbon black in order to bring out useful properties.

Although the nitriles are similar to rubber in being vulcanized with sulfur and rubber accelerators, and may be cured to hard rubber, they differ from rubber in other processing characteristics and in some operations are more difficult to handle.

During the war nitrile was essential as the lining of bullet-sealing gasoline tanks because of its good resistance to aromatic fuels. At the present time, uses of nitrile include applications where good strength and resistance to gasoline and oils are essential as for gas and oil hose, gaskets, and other mechanical goods. Nitrile cannot be considered to have replaced natural rubber in very many applications but rather it permits the use of rubber-like materials where natural rubber could never be used before.

Hard cellular rubber, made from GR-S, can be molded into any desired shape. If oil-resistance is a special problem, cellular rubber can be made from neoprene.
United States Rubber Company

NATURAL vs. SYNTHETIC RUBBER
Percent of Total U.S. Consumption



New Developments

A lighter-than-cork rubber for insulating refrigerators and freezing units was announced by the United States Rubber Company. Known as cellular rubber, it can be made in a hard or soft form. It is claimed to be more effective than cork as an insulator. It will not absorb moisture and is resistant to fire, rot, acids, oil, vermin and termites. It is recommended for refrigerator trucks, where present insulating materials absorb hundreds of pounds of moisture which add to the weight of the vehicle.

Cellular rubber is made by an expanding process in which chemicals containing nitrogen are mixed into a mass of rubber. The nitrogen upon release acts as a blowing agent. During the war it was used in the production of lightweight domes to protect delicate radar equipment and in the wings of airplanes as supports for fuel tanks.

Improved rubber mounts which virtually eliminate noise from the in-

terior of railroad cars are being produced for use in new passenger cars now under construction. The rubber is placed between the truck and body of the car, intercepting noise produced by the wheels rolling over steel rails. New sleepers and coaches equipped with the sound dampeners are claimed to be exceptionally quiet. Several different types and sizes are required on each car. One type must support 70,000 pounds of weight. They are designed to withstand millions of flexings under high stress without distorting permanently from their original shape. While rubber mounts were used on some railroad cars before the war, the new insulators have been redesigned to provide reduction of noise and vibration.

Copolymers

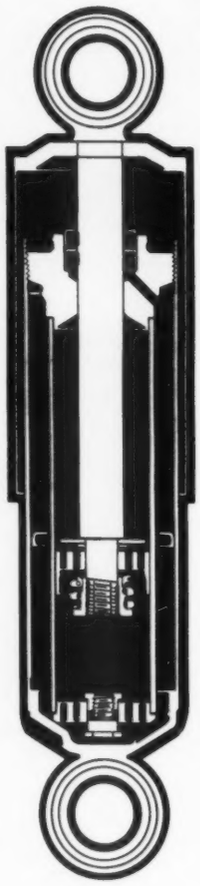
Approximately 80 synthetic rubber polymers were put into production last year, for all kinds of end products. Many of these experimental types were modifications of butadiene-styrene copolymers, resulting from the use of new emulsifiers and coagulatants. But others have involved the replacement of either the butadiene with another diene such as isoprene or the replacement of the styrene with either substitute styrenes or other vinyl compounds.

One of these modified GR-S copolymers provides extremely good building "tack"—a property essential for tire building. The incorporation of pigments at a considerably increased rate during milling is also claimed for some of these new copolymers. Others have provided the wire and cable covering industry with an elastomer of exceeding low water absorption.

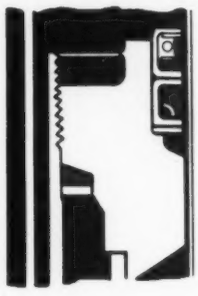
In extensive production are a whole new set of high heat-resistant elastomers. Some of these withstand continuous temperatures of 300 deg. F. and endure temperatures of more than 500 deg. F. for 8 to 10 hours. They can also be used effectively at temperatures as low as −70 deg. F. There will probably be many uses for these elastomers since they can be "tailor-made."

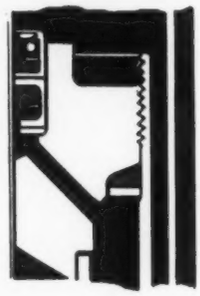
During the period of critical shortages of the war, the rubber industry investigated and tested various high molecular weight polymers belonging in the field of plastics. It was learned that many of these could be compounded or modified to give rubber-like elastomers. The materials performed so well in their new fields of application that the number of synthetic elastomers tripled. The distance between the rubber and plastics industry is growing smaller.

NEOPRENE INDUSTRIAL USES

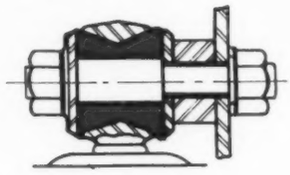


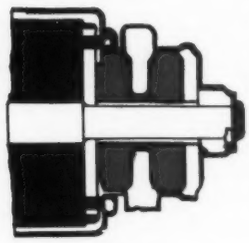
NEOPRENE SEALS prevent leakage of hydraulic fluid between piston rod and rod guide or through rod guide threads.





NEOPRENE GROMMETS





LOOP TYPE BUSHING, compressed at assembly, allows deflections either way of −20 deg. radial and 5 deg. axial.

STEM END TYPE BUSHING, compressed at assembly, allows up to 10 deg. angular movement in any direction.

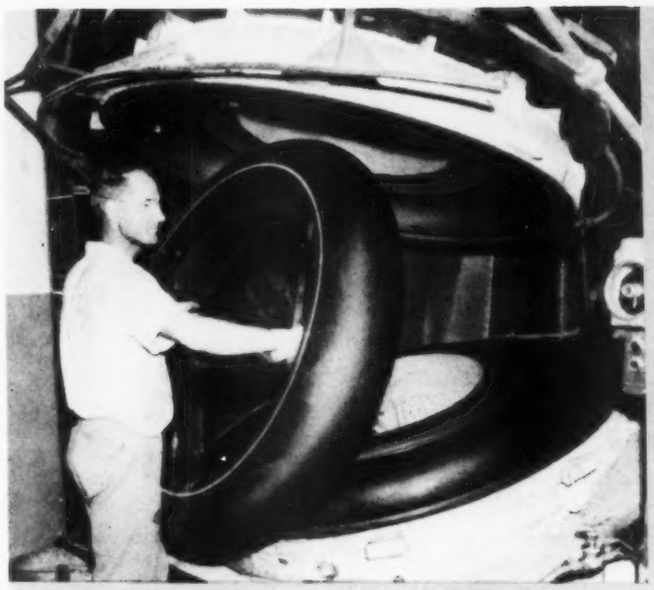
Neoprene seals prevent leakage in double action shock absorbers, used in automobiles, trucks, railway passenger and freight cars, on machinery, and for horizontal volute and torsion bar suspensions. Seals are not attacked by the hydraulic fluid, which is refined petroleum oil, blended with 2.5 to 3 percent of good grade fatty oil. Below, neoprene mounting grommets are used where toughness, durability and resilience are required.

Molded of hard nitrile rubber, basic requirement of this oil well packer is that it retains exact dimensions.

New Outlets for Latex

A new product in this field is foam sponge for cushioning of all kinds. Latex-bonded fibers are also used for the same purpose. Both foam sponge and bonded fibers are competing with and displacing conventional spring construction.

During the war newly developed synthetic latices replaced the natural



Huge inner tube is removed from curing mold. Made of butyl synthetic rubber, it holds air better than natural rubber and has greater tear resistance.

Early stage in production of butyl inner tubes is extrusion. Shown above is one of the largest sizes made, a 56-inch tube, being extruded.

product in practically all applications and it was found that many products made from synthetic latex had advantages over those made from the natural product. The advent of synthetics has enabled rubber processors to offer products having better aging, heat, oil and sunlight resistance. Synthetic latices, like dry polymers, can be so tailored as to enable the processor to use fabricating methods that would not be adaptable to the natural product. For example, synthetic latices can be made with a lower content of electrolytes and other non-rubber constituents than natural latex, the particles can be either positively or negatively charged, the surface tension can be varied over wide limits, as can the particle size.

Chlorinated Rubber

Derivatives of rubber, when chemically treated with hydrogen chloride or hydrochloric acid, are characterized by extreme oil and water resistance. One type of rubber hydrochloride is known as Pliofilm.

Chlorinated rubber, the result of treating natural rubber with chlorine, is produced by the Hercules Powder Company as "Parlon." Its resistance to solvents, and oils, except animal and vegetable oils, is excellent. Nonflammability is another characteristic. Five types of Parlon are produced for various applications: (1) In printing inks and as a fortifier for alkyd resin enamels; (2) in high-solids finishes; (3) as a film-former in protective coatings and as a fortifier in enamels and varnishes; (4) as a film-former in paper lacquers, adhesives and textile finishes; (5) as a film-former in finishes where flexibility is important.

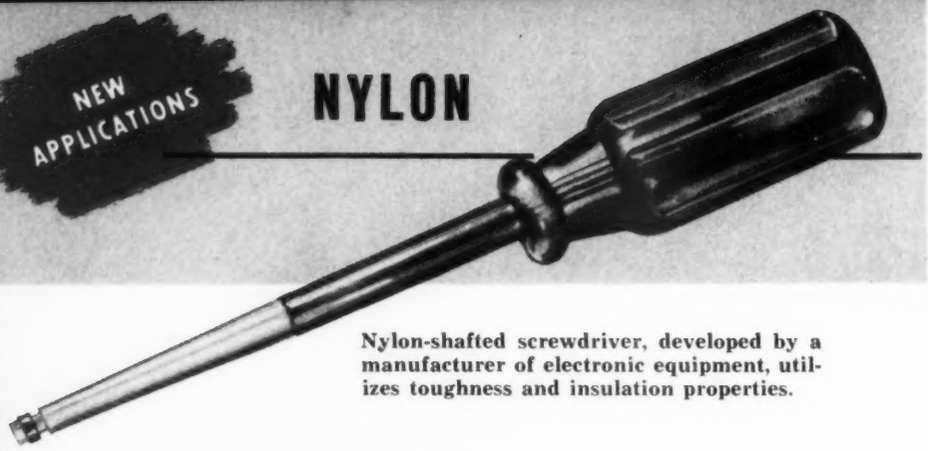
ELECTRICAL INSULATION

Properties	Polyethylene	Polystyrene	Polyisobutylene	Natural Rubber	
				Raw	Vulcanized
Dielectric strength—short time—v/m (0.125-inch sheeting)	460	500–700	400–500	500–700	500–700
Volume resistivity—ohm-cm	$>10^{13}$	10^{17}–10^{19}	10^{16}	10^{15}–10^{16}	10^{15}–10^{16}
Dielectric constant					
60 cycles	2.3	2.5–2.6	2.2–2.4	2.3–2.5	2.4–2.9
10^3 cycles	2.3	2.5–2.6	2.2–2.4	2.3–2.4	2.7
10^6 cycles	2.3	2.5–2.6		2.3–2.4	2.4–2.7
10^8 cycles	2.3				
Temperature stability of dielectric properties	excellent	excellent	excellent	excellent	excellent
Power factor					
60 cycles	<0.0005	0.0001–0.0003	0.0002	0.002–0.003	0.004
10^3 cycles	<0.0005	0.0001–0.0003	0.0005	0.001–0.002	0.004
10^6 cycles	<0.0005	0.0001–0.0008		0.001–0.002	0.004
10^8 cycles	<0.0005				

Du Pont Company

NEW APPLICATIONS

NYLON



Nylon-shafted screwdriver, developed by a manufacturer of electronic equipment, utilizes toughness and insulation properties.

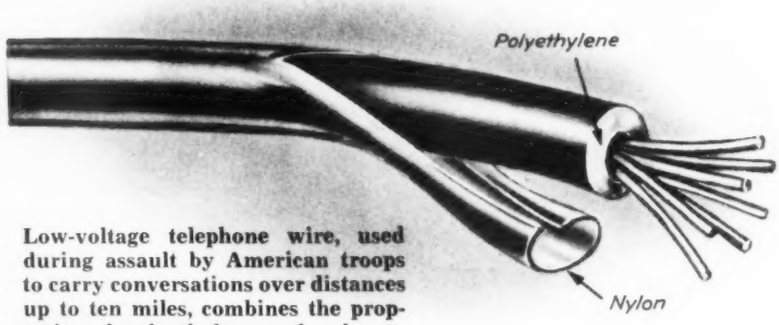
ORIGINALLY KNOWN as synthetic fibers, the polyamides or "nylons" were developed as molding materials during the war. Two main molding formulations are available: FM-1, melting at about 505 deg. F. and FM-3, melting at about 450 deg. F. Unlike the older thermoplastics which enter an indefinite "mushy" stage above their softening points, nylon molding powders have a sharp melting point and become extremely fluid. Molding temperature must therefore be closely controlled.

Molded nylon products show unusual bearing strength, heat resistance, toughness, and chemical and water resistance. Although both are good, FM-3 shows better moisture resistance than FM-1. (See December, 1946 issue of PRODUCT ENGINEERING for a full discussion of molded and machined nylon). A recent development has been the production of nylon rods and special shapes by the Polymer Corporation of Reading, Pa. These shapes can be machined to produce such products as valve seats, transformer coils, washers, insulating bushings, small gears, bearings for electroplating machines and pulleys. In machining nylon, highest possible speeds should be used and tools kept sharp. High speed steel or tungsten carbide give best results, and tools should be ground with a large clearance angle. This will avoid rubbing, which might be detrimental to the finish. Cooling fluids, hydrocarbons or soap solution, should be used.

New developments in this field include the production of leather-like, flexible nylon sheets, and thin films or foils of nylon. These can be used as replacements for leather, in packaging, and in wire covering.

Elastic Nylon

Elastic nylon, newest addition to the growing family of polyamides, has been made on an experimental scale. Copolymerized with synthetic rubber compounds, textile fibers



Low-voltage telephone wire, used during assault by American troops to carry conversations over distances up to ten miles, combines the properties of polyethylene and nylon to advantage.

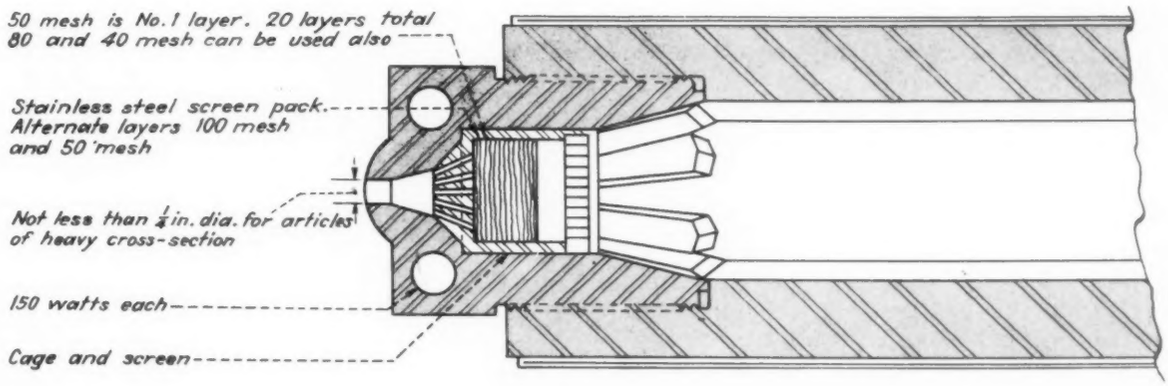
PROPERTIES OF MOLDED NYLON[a]

Properties	FM-1	FM-3	ASTM Test Method
Specific gravity	1.14	1.09	D71-27
Tensile strength: –70, 77, 170 deg. F., lb. per sq. in.	15,700; 10,530; 7,600	12,900; 7,600; 6,760	D638-42T
Elongation: –70, 77, 170 deg. F., percent	1.6; 54; 220	2.0; 75; 320	D638-42T
Modulus of elasticity, 77 deg. F., lb. per sq. in.	325,000	— — —	D638-42T
Flexural strength, 77 deg. F., lb. per sq. in.	13,000[b]	8,200[b]	D650-42T
Stiffness, 77 deg. F., lb. per sq. in.	290,000	152,000	D747-43T
Impact, Izod –70, 77, 170 deg. F., ft.-lb./in.	0.42; 0.94; 0.97	0.27; 1.34;[b]	D256-43T
Rockwell hardness	M 90	M54	D229-43
Flow temp., deg. C.	>250[c]	>250[c]	D569-43
Heat distortion temp., 264 lb. per sq. in., deg. F.	171	132	D648
Heat distortion temp., 66 lb., per sq. in., deg. F.	400	319	D648
Coefficient of expansion per deg. F., linear	5.7×10^{-5}	8.2×10^{-5}[d]	D696-42T
Thermal conductivity—BTU/hr./ft.^{2}/deg. F./in.	1.74	1.0	D325-31T
Dielectric strength—Short time-volt/mil	385 (0.125 in.)	470 (0.125 in.)	D149-40T
Dielectric strength—Step by step-volt/mil	— — —	410 (0.125 in.)	D149-40T
Volume resistivity, ohm-cm.	4.5×10^{13}	4.1×10^{14}	D257-38
Dielectric constant—60, 10^3, 10^6, 10^8 cycles	4.1; 4.0; 3.4; 3.24[e]	—; 4.5; 3.55; —	D150-42T
Power factor—60, 10^3, 10^6, 10^8 cycles	0.014; 0.02; 0.04; 0.036[e]	—; 0.042; 0.031; —	D150-42T
Water absorption, percent	1.5	0.44	D570-42T
Flammability, in 1 min.	Self-extinguishing	Self-extinguishing	D635-41T

[a]Source: E. I. DuPont de Nemours & Company.
[b]Specimen did not break.
[c]Exceeds limit of apparatus.
[d]77 to 140 deg. F.
[e]0.30 x 10^8 cycles.

MOLDING OF NYLON

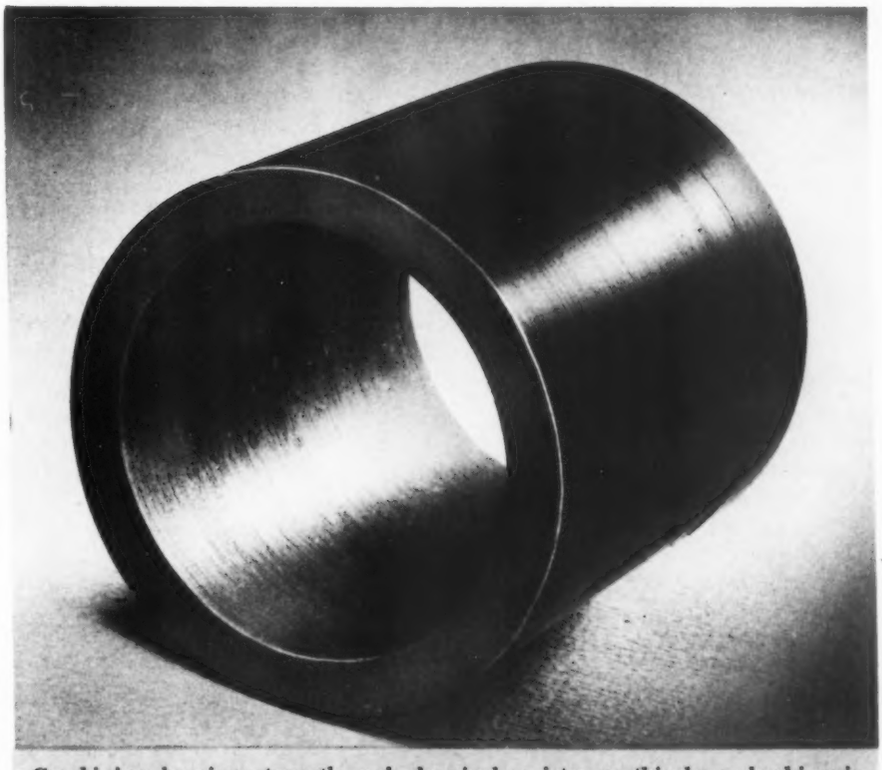
Nylon, because of its sharp melting point and extreme fluidity when melted, cannot be injection molded in the usual manner. Modifications include: (1) Molds should be drilled for the circulation of water and be operated at temperatures of 170 to 270 deg. F. A heated mold will permit operation with lower pressure on the injection cylinder, causing less development of strain in the molded product; it will also prevent premature solidifying of the nylon, thus permitting complete filling of the cavities and giving a high gloss to the finished article. (2) Nozzles for most products which would be made in a six ounce machine or larger should never be less than ¼ inch in diameter. Larger diameters and higher mold temperatures will increase the rate of filling of the mold. (3) Nozzle temperature should be the same as that of the downstream end of the cylinder. (4) Optimum temperature of the cylinder will vary with the number of screens employed to prevent oozing of molten nylon from the nozzle. (5) Injection pressure should range between 6000 and 18000 lb. per sq. in. (6) Precautions should be taken in closing the mold tightly and fitting the nozzle to the mold securely, to prevent a dangerous spurt of molten nylon.


50 mesh is No. 1 layer. 20 layers total
80 and 40 mesh can be used also
Stainless steel screen pack.
Alternate layers 100 mesh
and 50 mesh
Not less than ¼ in. dia. for articles
of heavy cross-section
150 watts each
Cage and screen

made from certain of these new nylons, technically known as "N-substituted polyamides," have elastic properties approaching those of rubber.

The elastic properties of these copolymers can be varied over a rather wide range, depending upon the molecular structure of the compound. One type, referred to as "isobutyl 610" can be stretched 250 to 400 percent, in comparison with 600 to 1100 percent for rubber. The elastic recovery of this nylon is of the order of 95 to 99 percent, in comparison with 100 percent for rubber. Nylon yarn of the type now used in hosiery, which has the highest combination of strength and elasticity of any fiber now in commercial use, has an elongation of only 15 to 25 percent.

Elastic modulus of the "N-substituted polyamides"—the force required to stretch it 100 percent—is about twenty times that of a corresponding rubber fiber, while its tensile strength is about five times as great. None of this material is now commercially available.



Combining bearing strength and chemical resistance, this large bushing is used on an electroplating machine, where corrosive conditions prevent use of metal bushings.

NEW APPLICATIONS

SILICONES

PERHAPS no single group of materials have appeared in so many new and different forms as the silicones. These materials, which have the silicon atom incorporated in the organic polymer, are noted for their high resistance, inertness and excellent dielectric properties. Forms available include resins, fluids and greases whose viscosity is not affected by extremes of temperature, electrical insulation that will not break down under extreme temperature and humidity conditions, paints that are resistant to high temperatures, and rubber that does not harden or crack on long exposure to high temperature.

Insulating Varnish

Another silicone product useful at high temperatures is Dow Corning's new DC 996 silicone insulating varnish. Curing at ordinary baking temperatures, DC 996 protects electrical equipment operating continuously at temperatures up to 350 deg. F. and subject to excessive moisture. When bonding and impregnating glass fibers, asbestos and mica, silicone varnish produces insulation for coils, motor stators, air-cooled transformers and other electrical machinery. The increased heat and moisture resistance obtainable from silicone varnishes is important in steel and textile mills, mines, chemicals plants, railroads, and hydro-electric plants.

Fluids

A new water-repellant material was announced by the General Electric Company. Originally developed to provide a water-resistant coating for fluorescent lamps, this fluid has a silicone base and forms a permanent film on drying.

The Dow Corning Corporation of Midland, Michigan, announced two new silicone fluids, DC 702 and DC 703, for use in high vacuum diffusion pumps. These fluids are being adopted for use in electron microscopes, metal evaporator systems, in the production of vacuum tubes, and in the dehydration of foods and pharmaceuticals.

Silicone oils are also being used in many high temperature lubrication applications. Although silicone oils are not miscible with petroleum oils and are not normally used in conjunction with them, one notable exception has been the use of a small amount of silicone oil in petroleum diesel oils in order to reduce their tendency to foam. Other uses of silicone oils are: Mold parting agents in plastics molding; non-flammable hydraulic and instrument fluids; liquid dielectrics, and special lubricants for glass, rubber, and plastics.

Silicone greases have been developed for high and low temperature lubrication. A special grease is available for pressure lubricated valves of the Nordstrom type. It is an effective lubricant and seal for automatic control valves and flow meter bearings, and it does not harden or melt from —40 deg. F. to over 500 deg. F. Special silicone greases have been developed for stopcocks and high vacuum systems.

Silicone Rubber

Silicone rubber, developed during the war, became available during the past year. Produced mainly by the General Electric Company and the Dow Corning Corporation, silicone rubbers are proving useful as gaskets and seals for extremely high and low temperature applications, or where corrosive liquids are encountered. In tests for heat stability run in hot dry air circulating ovens, a piece of synthetic rubber lasted for about 36 hours at 300 deg. F. while a silicone rubber specimen remained flexible for one year. The special virtue of silicone rubber is that it does not stick to metal surfaces at high temperatures. Applications include gaskets, O-rings and extruded sections in gas turbine engines, molded grommets used as bushings in a turbo-supercharger, and molded parts in a milking machine.

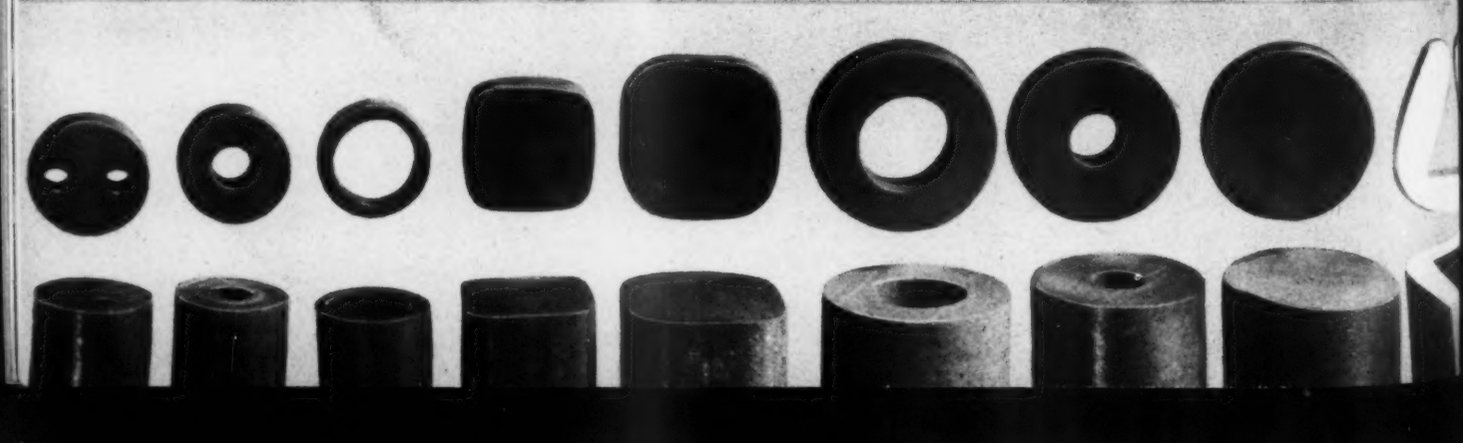
Resins and Laminates

The most recent addition to the silicone family is a thermosetting silicone resin known as DC 2103, developed by the Dow Corning Corporation. It is especially designed for use as a heat-stable bonding material for inorganic fabrics to produce rigid electric laminates, and for bonding finely divided particles such as powdered metals or mica, silica or carbon for friction-producing materials. The chemical resistance of this resin to all commonly used inorganic reagents except concentrated sulfuric acid is good. But perhaps the most interesting use of this resin is as a bonding agent for glass cloth and asbestos laminates.

Glass-silicone laminates are especially suitable where high strength, temperature resistance, or high dielectric strength is desired. Laminating pressures are around 1000 lb. per sq. in., at a temperature of 175 deg. C. A comparison of their properties with two other types of high pressure laminates is presented in the accompanying table. DC 2103 also forms a heat stable and waterproof cement for sealing light bulbs or radio transmitting tubes.

Silicones may appear in many new forms; existing types have already proven themselves in industry.

Samples of extruded tubes, rods and fabricated stock made of silicone rubber by the General Electric Company.



PHYSICAL PROPERTIES OF SILICONE FLUIDS

USES OF LIQUID SILICONES	Fluid Type	Viscosity Grade		Dielectric Constant at 1000 Cycles and 25°C.	Viscosity-Temperature Coefficient $1-\frac{V210°F.}{V100°F.}$	Freezing Point		Boiling Point		Flash Point Minimum °F.	Specific Gravity 25°C./25°C.	Lb. Per Gal. at 25°C.	Expansion Coefficient K x 1000 per °C. 25°C. to 100°C.	Refractive Index at 25°C.
		Cstks. at 25°C.	SSU at 100°F.			°C.	°F.	Temperature °C.	Pressure mm. Hg.					
Damping, hydraulic, and instrument fluids; Liquid dielectrics; Foam inhibitors; Mold release agents; Waterproof treatment for glass and ceramic insulators; Special lubricants for glass, rubber and plastics.	DC 500	0.65	28	2.18	0.31	−68	−90	99.5	760	30	0.761	6.35	1.598	1.3748
		1.0	29	2.32	0.37	−86	−123	152	760	100	0.818	6.84	1.451	1.3822
		1.5	30	2.40	0.46	−76	−105	192	760	160	0.852	7.11	1.312	1.3872
		2.0	31	2.46	0.48	−84	−119	230	760	195	0.871	7.27	1.247	1.3902
		3.0	33	2.52	0.51	−70	−94	70-100	0.5	225	0.896	7.48	1.170	1.394
		5.0	39	2.58	0.55	−70	−94	120-160	0.5	270	0.918	7.67	1.095	1.397
		10	50	2.65	0.57	−67	−88	>200	0.5	350	0.940	7.85	1.035	1.399
		20	75	2.68	0.59	−60	−76	>200	0.5	520	0.950	7.93	1.025	1.400
		50	185	2.72	0.59	−55	−67	>250	0.5	540	0.955	7.93	1.000	1.402
						Pour Point* (ASTM)		Volatility after 48 hr.						
						°C.	°F.	at °C.	percent					
	DC 200	100	355	2.74	0.60	−55	−67	200	<2	600	0.968	8.08	0.969	1.4030
		200	715	2.74	0.62	−53	−63	200	<2	615	0.971	8.10	0.968	1.4031
		350	1250	2.75	0.62	−50	−58	200	<2	625	0.972	8.11	0.966	1.4032
		500	1750	2.75	0.62	−50	−58	200	<2	625	0.972	8.11	0.965	1.4033
		1000	3500	2.76	0.62	−50	−58	200	<2	640	0.973	8.12	0.963	1.4035
High temp. baths; General temp. lubrication.	DC 550	100-150	300-400	2.87	0.75	−48	−54	250	<15	600	1.08	8.90	0.75	1.487
	DC 710	500	1060	2.88	0.89	−12	10	250	<15	600	1.11	9.25	0.71	1.523

*DC 200 Fluids are not recommended for use below about −40 deg. C. (−40 deg. F.)

COMPARISON OF VARIOUS TYPES OF LAMINATIONS

	FABRIC	Cotton	Glass Cloth	ESS 261 Fiberglas
	RESIN	Phenolic	Melamine	DC 2103
Flexural strength, lb. per sq. in.				
⅛ in. panel, flatwise		18,000	48,500	22,000
⅛ in. panel, edgewise		17,500	62,300	28,000
Tensile strength, lb. per sq. in.		9,000	30,000	15,000
Impact strength, ft.-lb. per in. notch				
Flatwise		4.0	29.0	13.0
Edgewise		2.5	12.5	10.0
Bonding strength, lb.				
½ inch panel		1,600	1,900	1,250
Water absorption, 24 hr., percent				
⅛ in. panel		1.25	1.45	0.21
Dielectric strength				
⅛ in. panel, volts per mil		200	260	250
Dielectric strength, step by step				
½ in. panel, kilovolts		35	45	50
Power factor, (D-24/25), percent				
1 mc.		10.0	2.7	0.51
100 mc.		—	—	0.97
Loss factor, (D24/25), percent				
1 mc.		60.0	19.5	1.95
100 mc.		—	—	3.15
Insulation resistance, wet, megohms		2.5	60	120,000
ASTM arc resistance, sec.		10	190	300
Heat distortion, deg. C.		135	200	>250

Physical Properties of Unfilled DC 2103 Silicone Resin

Specific gravity, at 25°C.	1.265
Refractive index, at 25°C.	1.47 to 1.49
Coefficient of linear expansion (0° to 100°C.)	.15 x 10^{-5}
Moisture absorption (ASTM D-570), percent	0.05 to 0.20
Dielectric strength, volts per mil	
(ASTM D-149) short time, dry	500
(ASTM D-149) short time, wet	450
Dielectric Constant (ASTM D-150)	
Dry at 100 cycles	2.86
Wet at 100 cycles	3.01
Dry at 1 megacycle	2.88
Wet at 1 megacycle	2.96
Power Factor (ASTM D-150)	
Dry at 100 cycles	0.00192
Wet at 100 cycles	0.00197
Dry at 1 megacycle	0.00158
Wet at 1 megacycle	0.00393
Loss Factor	
Dry at 100 cycles	0.0055
Wet at 100 cycles	0.0059
Dry at 1 megacycle	0.0046
Wet at 1 megacycle	0.0116

Properties of DC 996 Silicone Insulating Varnish

Property	Test Result	A.S.T.M. Test Method
Drying time at 150 deg. C., hr.	1-3	D-115
Heat endurance at 250 deg. C., hr.	100	D-115
Dielectric strength, dry, short time, volts per mil (¼ in. electrodes)	2500-3000	D-115
Water absorp. after 24 hr., percent	<0.1	D-570-42
Water absorp. after 7 days, percent	<0.15	D-570-42

Dow Corning Corporation

CELLULOSIC PLASTICS

NEW APPLICATIONS

PROPERTIES OF CELLULOSE PROPIONATE

Property	Formula Number				ASTM Method
	28102	28103	28209	28210	
Flow designation	H5	H4	H2	H	
Rockwell hardness	R96	R88	R78	R69	D-229-43
Specific gravity	1.21	1.20	1.19	1.19	D-176-42T
Distortion under heat, deg. C.	58	54	51	49	D-648-41T
Weight loss on heating 72 hr. at 82 deg. C. (180 deg. F.)	0.5	1.0	1.6	2.2	D-706-43T
Water absorption, percent (24 hr. immersion)	1.7	1.5	1.3	1.2	D-570-42
Soluble matter lost, percent (24 hr. immersion)	none	none	0.1	0.1	D-570-42
Elongation, percent	41	35.5	30	29	D-638-42T
Tensile strength, lb. per sq. in.	5090	4070	3290	2830	D-638-42T
Flexural strength, lb. per sq. in.	8300	6500	5800	5100	D-650-42T
Impact strength (Izod) ft.-lb. per in. of notch	1.5	8.3	10.3	11.4	D-256-43T

Celanese Plastics Corporation

CELLULOSE PROPIONATE—The newcomer in cellulosics, cellulose propionate, tradenamed "Forticel" by the Celanese Plastics Corporation, continues to be investigated to determine its particular niche. High surface luster, shorter injection molding cycles, complete freedom from odor and the ability to follow cellulose acetate butyrate in the injection machine, are among the important observations reported on the basis of field experience. Exhaustive field tests have shown that the performance of the new material has far exceeded expectations. Its dimensional stability was said to be superior to that of any of the cellulosics. Its surface gloss precludes any finishing operations. One large market for the new cellulosic is in injection molded housings for the new Eureka vacuum cleaners, which were previously compression molded of phenolic materials. In addition to the excellent finish and dimensional stability, toughness is a basic requirement in this application. Cost was brought down by the twenty percent reduction in molding cycle. Additional formulations of cellulose propionate have been developed, and properties for these are shown in the accompanying table. Prospective applications include flashlights, telephone housings, radio cabinets, steering wheels and camera cases.

Electrical properties of cellulose propionate are somewhat superior to cellulose acetate, in that the propionate has the same high dielectric strength but a lower power factor (0.015-0.020) and a lower dielectric constant (3.0-3.5). Because of the low moisture absorption of cellulose propionate, its electrical properties are little affected by atmosphere.

FACILE FABRIC—Another new development called "Facile Fabric" has been announced by the Celanese Plastics Corporation. This consists of lengthwise laminations of rayon material imbedded in cellulose acetate film. This is said to make an extremely high strength electrical insulating material, and is especially useful as a wire covering because of its strength in the lengthwise direction. For fire resistant applications a special formulation of cellulose acetate developed during the war, called Lumarith XF, can be used.

ACETATE—Cellulose acetate extrusions received wider use. One example of such use could be found in the conversion of the Lockheed C-69 "Constellation" from an army transport to a passenger liner. Five different types of extruded acetate strip, both in plain white and in color, were used to finish all seams, joints and retaining strips. The extruded strips are cut to the proper length, forced into seams or cracks, and held in place by a barbed flange. Because of their flexibility these strips are easily applied to square or rounded corners.

Strips of white cellulose acetate butyrate are snapped over aluminum retaining strips in the cabin of a Lockheed C-69 "Constellation." Other plastic strips in a variety of shapes and colors finish all interior joints.

Molded objects of cellulose acetate also found wider application. A typical example is the replacement of glass oil cups by oilers made of transparent cellulose acetate, resulting in a shatterproof product.

Broadening of the range of applications for cellulose acetate has been aided by the development of "high acetyl" acetate. A few years ago high acetyl acetate was considered of no industrial value because of its relative insolubility and high softening point, which made it hard to handle both in production and application. Today, however, a large percentage of all cellulose acetate being used is of the high acetyl type. The reasons are its higher water resistance and the improved dimensional stability of plastics articles made from it. To mold it, high molding temperatures are necessary and rather wide gates are desirable. There has also been a trend toward formulae designed to give greater rigidity and hardness.

Direct reading numeral wall clock, manufactured by Pennwood Numechron Co., has an ethyl cellulose case.

Keys of the Clary adding machine are double-injection molded of cellulose acetate butyrate in two colors.

ETHYL CELLULOSE – Applications for ethyl cellulose have greatly increased. The use of this tough plastic in the manufacture of the Proximity Fuze was indicative of its properties, such as dimensional permanence on exposure to all climates, heat resistance, high shock strength, excellent electrical characteristics and rapid moldability to close tolerances.

Ethyl cellulose is entering industrial fields where its excellent resistance to impact at low temperatures (–40 to –70 deg. F.), dimensional stability under ranges of temperatures and humidity, and its superior electrical properties make it suited for such applications as radio cabinets, refrigerator parts (dials, liners, evaporator doors, ice cube trays), flashlights, motor housings, and vacuum cleaner parts.

NEW MATERIALS

THERMOPLASTIC LAMINATES

A NEW DEVELOPMENT in the field of laminates that promises to have many industrial applications is the production of thermoplastic cellulosic laminates. These laminates are made of fabric or paper base materials bound with cellulose acetate or ethyl cellulose. Ease of fabrication by heat-forming and deep-drawing from flat sheets without many of the hand operations required in low pressure laminating, without complex or expensive equipment, opens up many possibilities.

Thermoplastic laminates based on cellulose derivatives differ from most other laminates in that the binding resin is tough and need not depend entirely on reinforcing for impact strength; this difference is especially striking when "three-dimensional" thermosetting polymers, having low impact strengths, are considered. Since the resins used are thermoplastic, they soften and fuse under heat with no chemical change taking place. This eliminates the danger of overcuring.

Fast and economical deep drawing and fabrication methods have been developed. The technique of laminating thermoplastic sheets is similar to general practice with thermosetting materials; but since no curing is required, all that is necessary is to heat the plastic to a suitable state of flow, apply pressure, and cool. The time cycle is governed only by the rate of charging and discharging the press plus the rate of heating and cooling it. Maximum pressure requirements are around 100 lb. per sq. in., and top temperatures of 375 to 385 deg. F. are required for the hardest formulas. A special fabric-coating machine has been developed by the Hercules Powder Company, to apply the thermoplastic resin. Molding powder of

COMPARISON OF CELLULOSIC THERMOPLASTIC LAMINATES WITH THERMOSETTING LAMINATES
(Tests in all cases were made on sheets 0.1 inch thick)

	A. S. T. M. Test No.	CELLULOSE ACETATE LAMINATES			ETHYL CELLULOSE LAMINATES			THERMOSETTING PHENOLIC LAMINATE TEST PIECES‡	
		Soft	Medium	Hard	Soft	Medium	Hard	Grade C	Grade LE
Specific gravity	D71-27	1.31	1.33	1.33	1.16	1.17	1.13	1.35	1.34
Hardness, Rockwell R Scale	D785	34	52	63	38	72	58	95 (M-Scale)	113 (M-Scale)
Izod impact strength*, ft. lb. in. notch	D256-43T	7.3	4.7	5.5	5.8	4.7	5.4	3.9	1.8
Izod impact strength, ft. lb./in.^{2}	D256-43T	18.3	11.6	13.8	14.5	11.9	13.4	9.7	4.5
Water absorption, immersion test, on drying before immersion, % loss	D570-42	2.2	1.66	1.60	1.33	1.40	1.41	2.00	2.26
2 Hours immersion, % gain	D570-42	0.91	1.40	1.40	1.36	1.0	1.85	0.42	0.91
24 Hours immersion, % gain	D570-42	2.5	4.79	4.7	4.8	3.32	4.6	2.0	3.2
48 Hours immersion, % gain	D570-42	2.83	6.2	6.2	7.0	4.59	6.2	2.7	4.2
Water absorption—100% R. H. ¶ 77° F.									
24 Hours, % gain		3.62	3.15	2.22	2.67	1.98	2.18	1.78	2.06
48 Hours, % gain		4.43	4.22	3.36	3.93	2.89	3.08	2.57	2.99
168 Hours, % gain		4.82	7.44	6.80	7.99	5.83	5.79	4.93	5.81
Tensile strength, lb./in.^{2}	D638-42T	4300	6400	8040	2940	5200	5370	8500	8000
Elastic modulus in tension, lb./in.^{2}	D638-42T	79000	310000	370000	59000	290000	337000	890000	850000
Flexural strength, lb./in.†		1600	7100	10400	1900	5500	5900	13000	22000
Distortion under heat, °C.	D648-41T	36	47.5	54	32	48	54	145	126
Thermal conductivity, cal./sec./cm.^{2}/°C./cm. × 1.0^{-4}	D325-31T	7.4	6.6	5.4	7.0	6.1	5.4	5.0	4.3
Thermal expansion, in./in./°C. × 10^{-5}	D696-42T	6	5	3	5	5	7	1.9	2.9
Elongation, %	D638-42T	10	8	8	7	9	7	3.2	1.3
Dielectric strength (Step by step—25°C.) (60 cycles—volts/mil.) Dry	D149-40T	320	390	360	370	470	480	290	360
Wet‖	D149-40T	25	20	210	80	110	70	20	80
Power factor (60 cycles—25° C.) Dry	D150-42T	.299	.103	.080	.038	.093	.071	.465	.34
Wet‖	D150-42T	.70	.70	.109	.135	.19	.045	.70	.66
(1,000,000 cycles—25°C.) Dry	D150-42T	.051	.058	.043	.044	.032	.029	.060	.057
Wet‖	D150-42T	.132	.30	.133	.100	.106	.107	.30	.122
Dielectric constant (60 cycles—25°C.) Dry	D150-42T	8.2	6.7	5.6	4.5	4.5	4.3	21.8	12.9
Wet‖	D150-42T	30	30	16.4	13.1	15.2	13.8	30	30
(1,000,000 cycles—25°C.) Dry	D150-42T	6.0	4.6	4.4	4.2	3.7	3.6	5.5	5.2
Wet‖	D150-42T	13.1	13.5	9.6	6.6	7.2	8.1	10.0	6.8

*Specimens, 1/8 in. thick, were stacked 1/2 in. high and run edgewise.
¶ R. H.—Relative humidity.
† Tested on Tour-Marshal by cantilever beam method.
‖ Wet specimens were immersed in water for 7 days at 25°C. and then tested.
‡ Tests conducted on commercial laminates 1/8 in. thick.

uniform size is fed through a hopper to a metal belt. The powder is softened in an infra-red oven and is then applied to the cloth on a squeeze roll. Instead of impregnating the fabric, the resin is "squeezed" into the cloth. This is a continuous process.

By selecting special textiles such as glass cloth for lamination, the impact strength as compared to unreinforced cellulose plastics can be tripled and sometimes quadrupled. Printed textiles can be laminated to produce many unusual decorative effects. Excellent electrical characteristics and low temperature flexibility are obtainable by selecting the proper plastic for binding. Applications include lightweight scuff-proof luggage, and automobile door panels and kick plates. Further industrial uses are under investigation by the Hercules Powder Company and the Celanese Plastics Corporation.

Placing the "layup" in the laminating press. The acetate coating is heated by steam to a fusible state and decorative facing material is pressed into the acetate. Various thickness can be built up. *Hercules Powder Company*

MOLDED PULP-RESINS

Paper pulp combined with thermosetting resins, developed by the Keyes Fibre Company of Waterville, Maine, are being molded into large, strong products, which can have thin sections and undercuts.

Pulp-resin preforms made to conform very closely to the desired dimensions of the finished article eliminate inherent deficiencies in ordinary thermosetting molding compounds. The press is fed with a pulp-resin mixture that is uniformly distributed throughout the die. The resulting flow that takes place during the actual molding operation is confined to the resin only, and the final molded product is therefore composed of a uniform material of continuous felted and interlocked fibrous reinforcing structure bound together by a synthetic resin. The molding is dense and hard with a smooth surface and possesses superior strength properties, especially high impact strength.

Typical applications include machine housings, switch and junction boxes, loop antennas for radios, drawer fronts for refrigerators, pistol grips, serving trays, collet and valve wheels.

PHYSICAL PROPERTIES OF MOLDED PULP-RESINS

GENERAL	
Colors	Medium to dark shades
Clarity	Opaque
Machinability	Good
Odor	None
Taste	None
Effect of:	
Age	None
Prolonged exposure to sunlight	Surface discoloration
Metal inserts	Inert
Boiling in water 24 hours	None
Boiling in mild soap solution 24 hours	None
Distortion after boiling in water 24 hours	None
Water Absorption – 48 hours, percent	0.22 to 2.39
PHYSICAL	
Specific Gravity	1.39 to 1.45
Specific Volume (cu. in./lb.)	19.1 to 19.9
Tensile Strength (psi)	4,500 to 9,000
Izod Impact Strength (ft. lbs. per in. of notch):	
Flatwise	1.76 to 4.4
Edgewise	0.87 to 1.63
Flexural Strength (psi):	
Flatwise	12,000 to 18,000
Edgewise	11,300 to 18,600
Compressive Strength (psi):	
Flatwise	22,800 to 35,200
Edgewise	15,800 to 21,500
Endwise	19,000 to 24,800

Keyes Fibre Company

Adding machine housing molded of paper pulp–thermosetting resin mixture shows good finish, high impact strength and excellent dimensional stability. *Keyes Fibre Company*

LOW PRESSURE MOLDING AND LAMINATING

NEW TECHNIQUES

ALTHOUGH not a new development in 1946, large volume use of low pressure laminates began last year. Production of these laminates has been made possible through the use of the comparatively new class of low pressure or "contact" resins. Two general types of resins are employed in low pressure laminating: (1) Polyesters, embracing the chemical groups of alkyds, alkyd-styrenes, and allyls; (2) phenolics which are "tailor-made" for low pressure molding. Low pressure laminating differs from high pressure methods in costs, tooling and overall techniques. While high pressure laminating requires from 1000 to 8000 lb. per sq. in., low pressure work is done in the range from ¼ to 15 lb. per sq. in., reducing the amount of expensive equipment used.

Low pressure-laminated parts can be made on cheap plaster molds, or with rubber blankets having vacuum drawn on the reverse side and are cured in ordinary ovens and heating tunnels. The small equipment outlay makes for lower cost of final product. Even more important than low cost, however, is the fact that low pressure techniques lend themselves to the production of molded parts of size and shape practically impossible to duplicate by other methods, except perhaps at a prohibitive cost.

The polyester low pressure resins exhibit interesting properties. Unlike conventional thermosetting resins, these materials do not give off any "condensation products," and thus exhibit high dimensional stability. When cast, these resins form a hard transparent material which can be furnished in many attractive colors. The B. F. Goodrich Chemical Company has marketed such a resin under the name "Kriston," the Du Pont Company under the name "BCM," and the United States Rubber Company, under the name "Vibron." Applications include cast lenses and prisms, special dial and indicator crystals, light shields, and lamp and illuminated sign parts.

GLASS LAMINATES—Low pressure laminating has come a long way since the production of Doron, a low pressure glass cloth laminate used for body armor during the war. All kinds of industrial parts, ranging from cargo compartments for freight airplanes to deep freeze units are being manufactured by low pressure methods. Materials used in combination with the low pressure resins include glass cloth, cotton, paper, rayon and

Properties of Vibrin-103 "Low Pressure" Resin

Uncured Resin	
Color	Light Straw
Viscosity, poise	2-5
Specific Gravity	1.15
Cured Resin (Clear Casting)	
Specific Gravity	1.28
Volume shrinkage on curing, percent	9.4
Unnotched Izod impact strength (room temperature), ft.-lb. per sq. in.	10.3
Flexural strength (room temperature), lb. per sq. in.	17,000
Youngs Modulus (room temperature), lb. per sq. in.	240,000
Rockwell Hardness (room temperature)	M80
Elongation at break, percent	5 to 10
Refractive Index	1.533
Electrical Properties	
Volume resistivity, ohm-cm.	6×10^{13}
Dielectric constant (50 cycles)	5.1
Loss factor (50 cycles)	0.17
Dielectric strength (0.005 in. sample) volts per mil	2,000

United States Rubber Company

Low and high pressure laminating methods combine in the interior panelling of the new De Soto station wagon produced by the Briggs Manufacturing Company. *Bakelite Corporation*

asbestos. Unusual high strength is exhibited by the glass cloth-low pressure laminates. Applications of these laminates include automobile body parts aircraft defroster ducts, tail cone assemblies and other aircraft parts, fenders for trailers, trunk lids, covers for hardwood forming dies and label holders on packaging machinery.

Low pressure laminates are particularly useful when reinforced with glass cloth or fiber. The high strength of glass fibers, combined with the binding action of the polyester resin, forms a structure of great importance to industry. Physical properties of the laminates can be varied over a wide range by suitably orienting the position of the individual glass fibers, proportioning the amount of fibers in the laminate, and orienting the fabric in the laminate. Physical properties of glass-plastic laminates, including energy absorption, tensile strength, compressive strength, flexural strength, impact strength and modulus of elasticity, greatly exceed those of 24ST aluminum and structural steel. A new technique of low pressure laminating with glass mats, known as "mat molding," has been developed. In this process glass mats are cut to a required "preform" size and are then loaded into the mold either with the blank already impregnated with resin or adding resin to the dry blank in the mold. The male and female halves of the mold are then closed and heat and relatively low pressure is applied. The molded part is then removed and the flash is trimmed off.

GLASS-RESIN LAMINATES — COMPARATIVE PROPERTIES

Property	Cross Laminated Glass Plastics	Parallel Laminated Glass Plastics	24ST Aluminum	Structural Steel
Tensile strength, lb. per sq. in.	55,000	77,000	40,000	45,000
Specific tensile strength*	31,500	44,000	14,300	5,770
Compressive strength, lb. per sq. in.	54,000	68,000	43,000	45,000
Specific compressive strength*	3,800	38,800	15,300	5,770
Flexural strength, lb. per sq. in.	84,000	113,000	64,000	45,000
Specific flexural strength**	27,400	36,800	8,200	740
Izod impact, ft.-lb. per in.	30	54	24	45
Specific impact strength	17.1	31	8.6	5.8
Modulus of elasticity, lb. per sq. in. x 10^6	2.5	4.2	10.5	29
Specific modulus of elasticity	1.4	2.4	3.75	3.7
Percent elongation	2.0	2.0	0.4	0.2
Relative energy absorption***	110,000	154,000	16,000	9,000

* Specific tension and specific compression are obtained by dividing the strength values by the specific gravity of the material, to reduce them to a strength-weight basic.
** Obtained by dividing flexural strength by the square of the specific gravity.
*** Product of percent elongation and tensile strength—energy required to permanntly deform material.

This strong, lightweight sink is made of glass fiber warp mat bonded with Du Pont's BCM, a low pressure laminating resin. Colors can be incorporated directly in the resin.

HIGHER PRESSURES—An application of low-pressure laminating methods to the automotive field which is in actual production is the manufacture of interior parts of the new De Soto station wagon, at the plant of the Briggs Manufacturing Company in Detroit, Michigan. In this car, four laminated door panels, two rear quarter panels, one rear deck, and two strips mounted between the doors are being laminated from a cellulose paper core impregnated with a phenolic resin, which is faced with a high strength paper. Technically this process is classified as low pressure, but many high pressure elements are present. Pressures used are about 500 lbs. per sq. in., higher than "normal" low pressures, but still far below high pressures. High strength paper impregnated with special phenolics are cut to shape and placed in position on a core consisting of heavy alpha cellulose paper. The entire sandwich is then placed in a laminating press and cured at a temperature of 350 deg. F., for 1½ min., after which the cured laminate is held flat in a wooden die until cooled. The panels are then heated by infrared lamps to approximately 300 deg. F. for subsequent die cutting and stamping operations. Some of the parts, such as the panels for the rear deck and rear quarter section are "postformed" to shape in simple wooden forming dies. The plastics industry predicts that low and high pressure methods will find greater compatibility in the future.

Previous applications of low pressure laminates in any volume in the automotive field include decorative laminates in taxicab interiors and laminated sun visors in trucks.

HONEYCOMB-SANDWICH STRUCTURES

NEW MATERIALS

"HONEYCOMB" or expanded structural plastics are claimed to have an extremely high strength-weight ratio. With an internal structure of numerous cells resembling a beehive, cores of these materials consisting of resin-impregnated cloth, paper or glass cloth, honeycomb or foamed plastics are bonded between aluminum, stainlessless steel, wood veneer, or plastic sheets to form strong, lightweight, waterproof structural plastic panels. In these laminates the core material selected is determined by the end use desired. For most commercial applications, paper or cotton fabric impregnated with phenolic resins are satisfactory. However, where electrical properties are important, glass cloth impregnated with a polyester or "low-pressure" resin may be required.

Weight of the core material used can be varied to conform to the stress that the finished product will be required to carry. Standard cotton cloth honeycomb weighs 3¾ lb. per cu. ft., while that made from paper weighs from 1 to 3½ lb. per cu. ft. Type of facing and thickness will also vary with load requirements. Honeycomb sandwich panels can be made flat with the dimensional stability of metals, and they can also be produced with compound curves. Also it is easy and economical to fabricate and to assemble. Because of these lightweight, high strength and economical characteristics, honeycomb constructions are being widely adopted in industry for hundreds of uses.

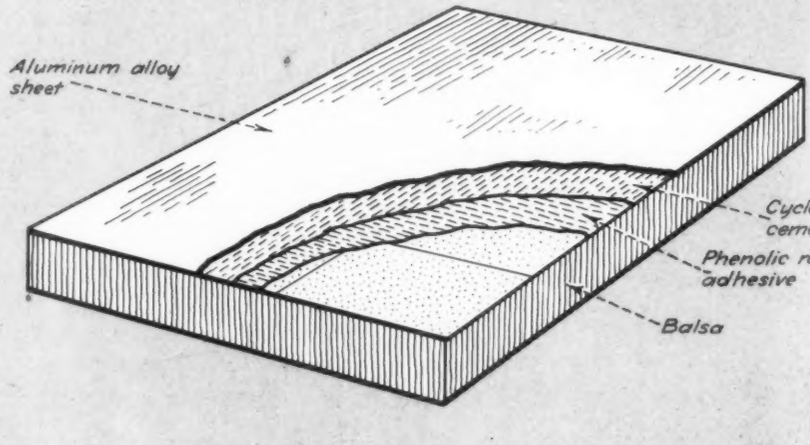
The United States Plywood Corporation, in cooperation with the Glenn L. Martin Company, has developed a honeycomb sandwich flooring for the Martin 202 twin engine transport plane, designed to take primary loads as part of the fuselage structure, resulting in a 35 percent saving in weight and a 30 percent increase in strength. Honeycomb constructions are also finding a place in other forms of transportation. Through economies in fabrication and because of the weight saved, honeycomb panels are being used in industrial trailers, railroad passenger cars and house trailers. Honeycomb panels for doors, shelving, tabletops, work surfaces, and airducts are being faced with thin stainless steel skins.

Not all sandwich structures, however, utilize honeycomb core materials. A sandwich material manufactured by the United States Plywood Corporation, under the trade name of Tekwood, is constructed of a hardwood core bonded to two faces of heavy cylinder craft paper, each element with opposing grains. Urea-formaldehyde adhesive is employed. Tests have shown that Tekwood has superior strength characteristics to solid lumber of equal thickness, and is more flexible and more economical. One application for Tekwood is in center pillar posts for four-door sedans manufactured for General Motors by Fabricon Products, Inc. of River Rouge, Michigan. This material lends itself readily to fabrication processes, especially die-cutting.

Other Cores

Sandwich structures with foamed plastic cores are finding wide use in the refrigerator industry. The Cycleweld Division of Chrysler Corporation is using this type of construction in their new walk-in refrigerator. Special features of interest are: (1) Stressed aluminum skins with expanded plastics cores; (2) all hardware anchored in the sandwich without the use of through-bolts or wood frame members. No structural frame other than panels; (3) panels joined by locking wedge clips driven in place by hammer blow; (4) ventilated sub-floor of corrugated aluminum bonded to flat aluminum sheet with cycleweld cement.

ARRANGEMENT OF BALSA CORE IN "METALITE" SANDWICH



	Aircraft Metal	"Metalite"
Ratio, Strength/Weight	1.00	1.74

Chance-Vought Division
United Aircraft Corporation

A highly efficient aircraft sandwich laminate has been developed by the Chance Vought Aircraft Division of the United Aircraft Corporation, in cooperation with the U. S. Navy Bureau of Aeronautics. Requirements for aircraft sandwich laminates include strength that must compete with the all-metal construction of present day aircraft. Chance Vought has concentrated its efforts largely on an aluminum-faced balsa core combination which has been given the trade name "Metalite." As shown in the accompanying drawing, it was found advantageous to arrange the balsa with the grain of the wood normal to the metal faces. A two stage bonding operation is employed; in the first stage Cycleweld C-3 cement made by the Chrysler Corporation is cured on the metal faces only. Final bonding of the faces to the core is accomplished with a medium temperature phenolic adhesive. This sandwich laminate has proved successful in the airframe of two types of experimental naval aircraft and in the stabilizers of the F4U Corsair airplane.

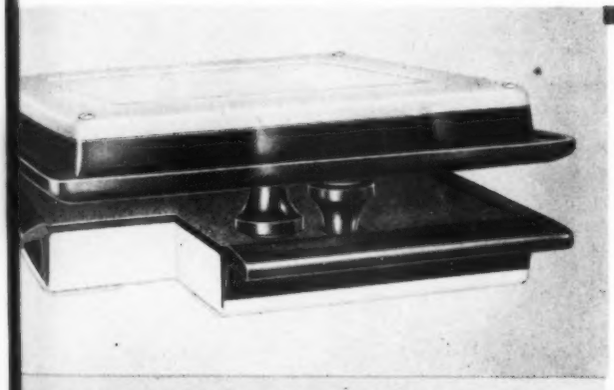
PHYSICAL PROPERTIES OF HONEYCOMB
Tests conducted by United States Plywood Corporation

Core Material[1]	Density lb. per cu. ft.	Shear Strength[2] p.s.i.	Shear Modulus[3] p.s.i.	Compress. Strength p.s.i.
4 oz. Cotton sheeting	3.75	140	9,000	340
8 oz. Cotton Duck	7.8	248	13,000	710
Fiberglas Cloth ECC 128 cloth	5.75	150[3]	9,000[3]	350[3]
11 Mil Paper	3.5	180	17,000	360[3]
Asbestos Paper	4.5	160[3]	11,000[3]	350[3]

(1) All material was impregnated with a phenolic type resin except the Fiberglas cloth which was impregnated with a polyester type resin.

(2) Parallel to Corrugations — Preliminary test results indicate that the corresponding values perpendicular to corrugations will be approximately 50% of these values.

(3) Values are estimates based on preliminary information and are believed to be conservative.



tweight ice cream cabinet lid, constructed of molded styrene and insulated with foamed polystyrene, gned by Frigidaire Division of General Motors.

PROPERTIES OF PLASTIC FOAMS

Property	Cellular Cellulose Acetate		Styrofoam
	CH-145	CH-167	103.7
Density, lb. per cu. ft.	4.5	6.7	1.55
Tensile strength	95	175	60
Compressive strength, lb. per sq. in.	75	125	20
Compression modulus, lb. per sq. in.	3,500	5,500	950
Thermal Conductivity, Btu sq.ft./hr./deg.F./ in.	0.30	0.31	0.27

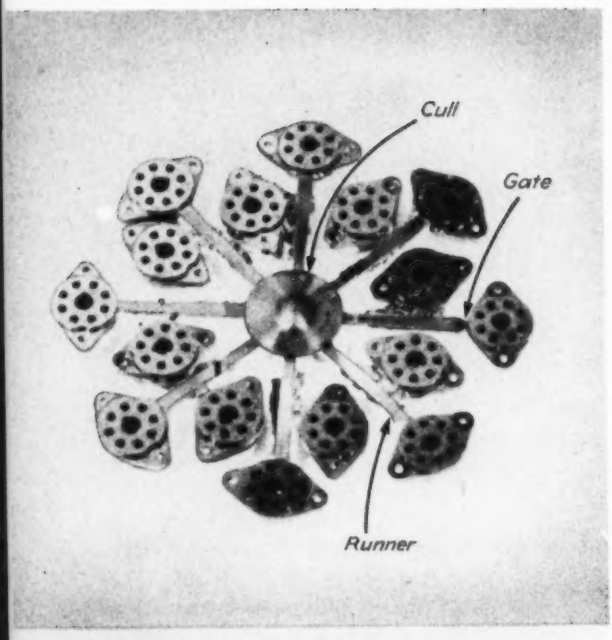
FOAMED PLASTICS

OUT OF THE SEARCH for high strength lightweight materials, expanded plastics have come as one answer. Many resins are being offered in foamed form, either rigid or non-rigid and with or without individually sealed cells. Their usefulness is being explored particularly for thermal insulation and for structural functions in aircraft where high strength-weight ratios are required.

CELLULAR CELLUOSE ACETATE — A new foamed plastic, called cellular cellulose acetate or "CCA," was developed by the Du Pont Company. Combining great strength with extremely light weight the new material is envisioned for use as the core material in airplane floor panels, tail assemblies, and wing structures, and in refrigerators, luggage and sections of prefabricated houses. Although lighter than balsa or cork, the thermal insulating properties of CCA are virtually the same. Heat resistance is such that thermosetting resins can be used to cement it. CCA is available in four ranges of density: 4-5, 6-7, 7-8, and 8-9 lb. per cu. ft. Aluminum, magnesium, steel and stainless steel can be bonded to cellular cellulose acetate.

POLYSTYRENE FOAM -- Polystyrene is a natural product for a plastic foam because of its low thermal conductivity, low water absorption, low cost and relatively high modulus of elasticity. A product of the Dow Chemical Company of Midland, Michigan, Styrofoam 103.7 is available in commercial quantities in a density of 1.3 to 2.0 lb. per cu. ft. Experimentally, it has been produced in a much wider range of densities, but facilities are not yet available for commercial output. As with other foams, properties vary with density. Applications indicated are as a buoyant medium, as a filler in sandwich structures, and as a low temperature insulation. Styrofoam-filled buoyant chambers are being used in boats of all sizes to guarantee permanent buoyancy. Risk of punctured or corroded metal chambers is eliminated. Properties of Styrofoam make it desirable for a wide variety of refrigeration applications. Ease of handling and installation add to the economy of this material.

NEW TECHNIQUES BROADEN P

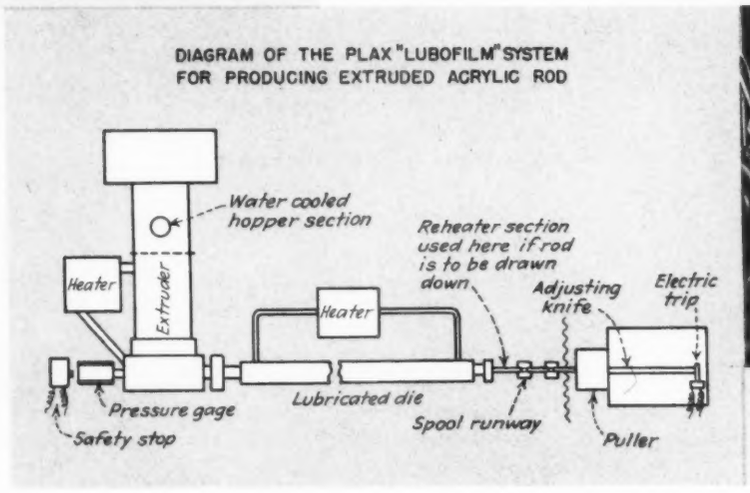


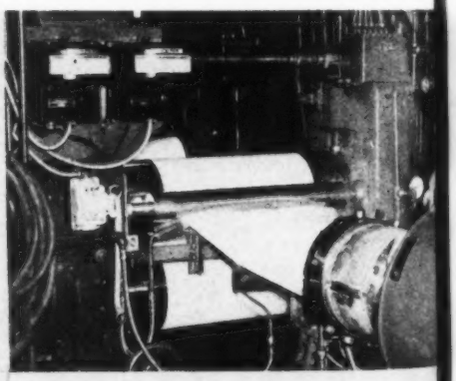
Complete shots of radio tube sockets as ejected from an auxiliary plunger transfer mold. *Shaw Insulator Company*

AUXILIARY PLUNGER TRANSFER MOLDING

AUXILIARY PLUNGER transfer molding, used in conjunction with radio frequency or steam preheating and properly designed molds, is the modern answer to the problem of molding phenolics at a profit, under existing conditions of increasing costs and serious lack of facilities for expansion. Conventional compression molding is a relatively slow process, and results in relatively low production for each charge. In the auxiliary plunger method, the transfer chamber is a sleeve, the movable bottom of which opens directly into the runners. This makes a sprue unnecessary and reduces the length of flow path to the cavities. The movable bottom of the transfer chamber pulls away when the mold is open. The transfer piston is actuated by an auxiliary cylinder independent of the main press ram, which clamps the mold halves shut previous to molding. Time of transfer is thus cut down considerably. Production of small parts in large volume is well suited for this method; the process becomes almost continuous and the amount of "cull" that must be removed is small, since no sprue is present.

This method is especially useful where difficult undercuts are required, and where fragile inserts, high dimensional accuracy and low original mold cost are factors in design of thermosetting plastics products.





Equipment developed for nonsolvent continuous extrusion of cellulosic plastic sheeting. *Tennessee Eastman Corp.*

THERMOPLASTIC EXTRUSION

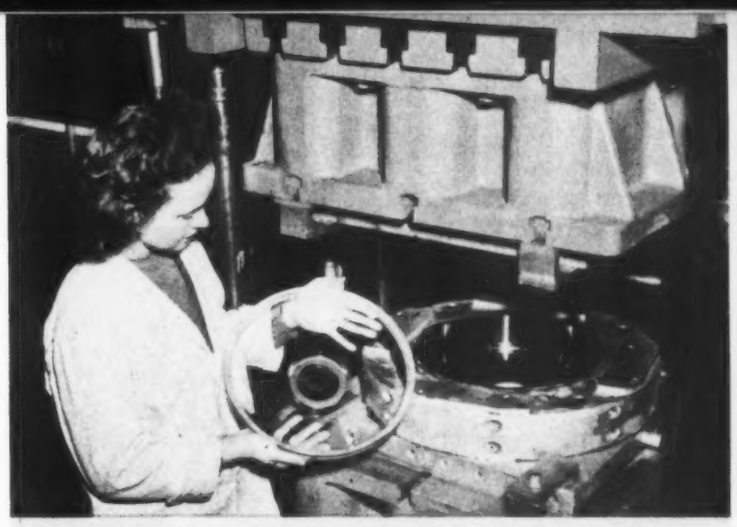
ESPECIALLY noteworthy advances were made in techniques of thermoplastic extrusion. One of these related to the production of cellulose acetate and acetate-butyrate sheeting in widths up to 24 inches by a non-solvent continuous process using a standard extruder. Another method reported by Mr. James Bailey, vice-president and research director of the Plax Corporation, concerned the methods found to be best suited for extruding acrylic resins. The extrusion of acrylic resins is similar to the extrusion of other thermoplastics except in two major respects: (1) The acrylics, when extruded at temperatures necessary to give a good surface and structure are prone to develop bubbles due to the breakdown of plastics into the gas monomer; (2) they are premium materials requiring relatively high standards of clarity, color and dimensional tolerance to justify their use in major industrial applications.

PLASTICS USES

MOLDING TELEVISION LENSES

IN THE ANNUAL MEETING of the Society of Plastics Engineers held in Chicago during the last week in January, Mr. R. V. Beshgetoor, Manager of the Plastics Department, Radio Corporation of America disclosed that acrylic lenses are being compression molded by RCA for use in projection-type television receivers. It was found that metal, not glass molds are necessary in the molding of true optical lenses, which, when combined with spherical mirrors form the Schmidt system of reflective optics. Before metal molds could be produced it was necessary to build a high precision mold measuring device which could measure the curvature of the mold surface accurately and quickly to within one millionth of an inch.

A semi-positive compression mold was used in the lense production. Advantages of this type of molding are: (1) Reduced material handling; (2) accurate control of charge; (3) accurate control of clamping force and mold alignment; (4) control of gate position, with no possibility of resulted strains set up in the molded part.



Semi-positive compression molding of acrylic television lenses. Conventional injection procedures produced unsatisfactory optical products. *Radio Corp. of America*

THERMOSETTING EXTRUSION

PHENOLIC MATERIALS are now being extruded. Thermosetting extrusion is not like transfer or compression molding, where the final cure is effected only after complete movement of the material has taken place. In thermosetting extrusion the flow and cure are concurrent.

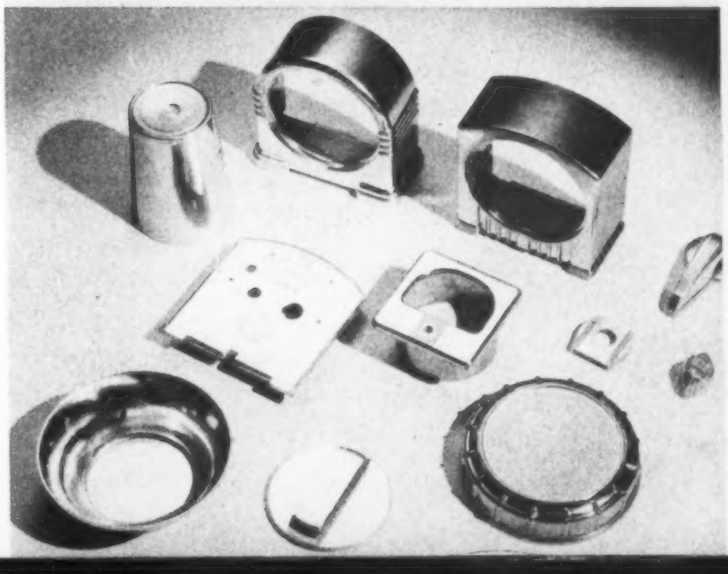
Two types of machines have been used in thermosetting extrusion. One has a screw with intermeshing baffle gears while the other employs a reciprocating piston. The piston type lends itself more readily to small parts than does the screw type. Best results have been obtained from a phenolic semi-impact macerated paper-filled material, particularly in the production of tubing. Indications are that thermosetting extrusions could replace laminated tubes and rods in specialized applications, and provide better dielectric properties, water resistance, finish and dimensional tolerances. Possible applications include electrical conduit, insulation, coil forms, and corrosion-resistant piping. *(Information furnished by Mr. Gustave Holmgren.)*

METAL COATING OF PLASTICS

THE USE of vacuum evaporation was expanded to include coating the surface of both plastic ornamental and industrial products. This method of metal coating had been established during the war for the coating of glass optical surfaces with both low-reflecting materials such as magnesium fluoride and with metals such as aluminum, silver, gold, rhodium and chromium for use as front-surface reflectors. The most commonly encountered metals including aluminum, copper, gold, silver, chromium, cadmium, zinc, nickel and tin can all be evaporated without serious difficulty.

Metal coatings can also be put on plastics by other methods, such as adhesives, metal spraying and electroplating. Some advantages and applications of metal coated plastics are: (1) Electrical conductivity—airplane and antenna masts, direction finding loops, shielded housings, condensers, special computators, and contacts for electrical leads; (2) light reflection—mirrors; (3) weight —lightweight objects used in aircraft requiring metal surfaces; (4) heat resistance — applications involving localized heating; (5) corrosion resistance; (6) color and decorative effects. The National Research Corporation of Boston, Massachusetts, has been largely responsible for research in the vacuum evaporation method, while the Metaplast Company, New York, N. Y. is the leader in the fields of electroplating, spraying and solution deposition of metals on plastics.

Plastic products coated with various metals by the vacuum evaporation process. *National Research Corp.*



LARGE-SIZED INJECTION MOLDINGS

AN EVIDENT TREND in the plastics industry is the building of injection molding machines for producing comparatively large-sized plastics and rubber parts. This enables the designer to take advantage of the superior physical properties of thermoplastics in larger objects. New machines for this purpose are being constructed by the Watson-Stillman Company, the Hydraulic Press Manufacturing Company, and the Improved Paper Machinery Corporation. Other advantages of large-sized injection moldings include economy and a wide range of colors, including transparent and translucent sections, which cannot be obtained in thermosetting materials. Some examples of larger injection molded objects are the dash panel of the Ford automobile which runs the entire width of the car, radio cabinets, and telephone hand sets and bases.

Side-sections for the new Kelvinator refrigerator, 31⅛ in. long, with a projected area of 120 sq. in., were molded of white polystyrene on a 16-ounce press built by the Hydraulic Press Manufacturing Company.

WE WISH TO THANK...

the following members of the plastics industry for their cooperation in supplying background material and data:

American Cyanamid Company
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Celanese Plastics Corporation
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Cycleweld Division, Chrysler Corporation
Dow Chemical Company
Dow Corning Corporation
E. I. Du Pont de Nemours & Company
Enjay Company, Incorporated
Firestone Tire and Rubber Company
Frigidaire Div., General Motors Corporation
The General Electric Company
Glenn L. Martin Company
B. F. Goodrich Chemical Company
B. F. Goodrich Rubber Company
Goodyear Tire and Rubber Company
Hercules Powder Company
The Hydraulic Press Manufacturing Company
Keyes Fibre Company
Metaplast Company
Monsanto Chemical Company
National Research Corporation
Owens-Corning Fiberglas Corp.
Plaskon Div., Libby-Owens-Ford Glass Company
Plax Corporation
Polymer Corporation
Polyplastex, Incorporated
Rohm & Haas Company
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ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Comparison of Magnet Wire Properties

From paper "Properties of Magnet Wire" by H. A. Smith and W. G. Skinner, General Electric Co., presented at Great Lakes District A.I.E.E. meeting, October 1946, Indianapolis, Ind.

MOST COMMON TYPES OF MAGNET WIRE ARE: (1) Enamel or film coated; (2) cotton covered; (3) silk covered; (4) nylon covered; and (5) glass covered. In the electrical industry film coated copper wire is the most important. More than half of the 200 million lb. of magnet wire used in a normal year is film coated and an additional 20 percent has a film coating plus a covering such as cotton, nylon or glass.

Film Coated Wire

The two main types of wire enamels in use today are synthetic resin enamels and oleoresinous enamels. Film coated magnet wire is normally made in sizes 0.001 to 0.128 in. in dia. The 0.001 in. dia. wire contains 330,000 ft. per lb.; 0.128 in. dia. has only 20 ft. per lb. A film coating is the only type of insulation that can be put on wire sizes as small as 0.001 in. in dia.

Of the several types of synthetic resin wire enamels now in use, the major one is an enamel based on polyvinyl acetal resin. In general the physical properties of a polyvinyl acetal coated wire are far superior to those of a natural resin enamel film coated wire. In the discussion of tests, comparison is made between oleoresinous enameled wire and polyvinyl acetal wire. Oleoresinous enamels are essentially natural resins with drying oils such as linseed, perilla, and china wood oil. Polyvinyl acetal enamel is an organic synthetic basically derived from coal.

DIELECTRIC STRENGTH. There is no important difference between the initial dielectric strength of polyvinyl acetal wire and that of oleoresinous enameled wires. The difference develops during the winding, assembly, varnish treatment, and life of the apparatus in which the wire is used. Polyvinyl acetal wire, because of the physical properties of the insulating film, gives greater assurance of maintaining its dielectric strength after exposure to the physical forces that are encountered during assembly and service.

The initial dielectric strength of film coated magnet wires is commonly measured by twisting together two lengths of wire and gradually applying voltage until breakdown occurs. Wire insulated with double enamel or heavy vinyl acetal, when subjected to this test, normally produces a dielectric breakdown of approximately 1,500 volts per mil of insulation thickness.

POWER FACTOR. The power loss of a radio-frequency coil depends in part on the dielectric power loss in the insulation. Dielectric power loss at a given voltage stress and frequency is proportional to the dielectric constant and to the power factor of the insulation. The product of these, called loss factor, is much used in radio engineering as a criterion of insulation quality. Table I compares these factors for polyvinyl acetal and conventional enameled wire.

ABRASION RESISTANCE. The ability of an insulating film to resist damage during winding, treatment, and service, is a function of its physical characteristics. The best insulation electrically is useless unless it has the physical toughness to resist abuse during the manufacture of apparatus.

Perhaps abrasion resistance is the best single measure of film toughness and this property is shown in Table II.

FLEXIBILITY. Another indication of film toughness is flexibility or extensibility. This is the amount the film can be elongated without cracking. Polyvinyl acetal insulated wire can be stretched 25 percent then wound on a mandrel three times the dia. of the bare wire without cracking of the film.

RESISTANCE TO HEAT SHOCK. Cracking of a stretched enamel film subjected to high temperature is called heat shock. It is a flexibility measurement at high temperature and is usually measured by winding wire on a mandrel and subjecting the sample thus prepared to a temperature of 150 deg. C. for one-half hour. After removal from the oven and cooling to room temperature, the samples are inspected for cracks. A polyvinyl acetal wire will not show cracks

Table I—Comparison of Electrical Characteristics

	Conventional Enameled Wire		Formex Wire	
	30 deg. C.	75 deg. C.	30 deg. C.	75 deg. C.
Power Factor	0.0085	0.0360	0.0076	0.0046
Dielectric Constant	3.0	3.6	3.6	3.4
Loss Factor	0.025	0.13	0.027	0.016

Table II—Comparison of Abrasion Resistance

AWG. No. 14 Dia., in.	Type Film	Avg. scrapes to failure	Load, grams
0.0641	Heavy Formex	60 to 70	880
0.0641	Double enamel	3 to 6	880

after this test, but a conventional enamel wire will crack severely.

HEAT AGING. Magnet wire is subjected to temperatures above the ambient for long periods of time throughout the life of a machine. This causes aging of the film. Under this aging, the film tends to become harder and more brittle. Table III shows a comparison of heat aging tests.

SOLVENT RESISTANCE. In the varnish treatment of electrical apparatus the film on wire is subjected to a great many commonly used solvents and must resist them. See Table IV.

TEMPERATURE RATING. Both polyvinyl acetal insulated wire and the conventional enamel insulated wire fall under the A.I.E.E. standards for Class *A* insulating materials which have a temperature rating of 105 deg. C.

Table III—Comparison of Endurance in Heat Aging

Temperature, deg. C.	Ratio of endurance of Formex wire, before breakdown, to that of enameled wire
105	60 times
125	10 times
150	6 times

WINDING SPACE FACTOR. Since the film on film coated magnet wire is extremely thin, about 2½ mils increase in diameter for 0.032 in. (AWG. No. 20) double enamel or heavy polyvinyl acetal, the winding space factor for such wires is considerably greater than that for fibrous insulated magnet wires, as shown in Fig. 1. Magnet wire is purchased by the pound but is used by the foot. Because there are more feet of wire in a pound of film coated wire than of any other type important savings can be realized, especially in the finer sizes. For sizes No. 37 AWG. there are 15,000 ft. of heavy polyvinyl acetal wire per lb. as compared with only 11,600 ft. per lb. of enamel single cotton.

COPPER STIFFNESS. In forming magnet wire into coils, hardness or stiffness of the finished wire is often an important factor. Copper wire that has been improperly annealed or hardened by bending during the insulating operation may be so stiff that it will not readily wind to the coil form. In general, both the wire manufacturing equipment and apparatus winding equipment are at present so designed that excessive work hardening of copper magnet wire occurs on both types of equipment.

Table IV—Comparison of Resistance to Solvents

Solvent	Heavy enamel	Heavy formex
Kerosene	Slight softening	No. effect
Toluol coal tar	Fails	Slight softening at 4,000 hr.
Petroleum naphtha	Slight softening	No. effect
Alcohols (Methyl through octyl)	Fails	No effect
Xylol coal tar	Fails	Slight softening at 4,000 hr.
Acetone	Fails	No effect
Trichlorethylene	Fails	75 percent softening
10 percent Sulfuric acid	No effect	No effect
1 percent Potassium hydroxide	No effect	No effect
Freon F-12 gas	Fails	No effect
Cresol plus alcohol	Fails	Fails
Ammonia	Slight softening	No effect after 72 hr.
Gasoline	Fails	No effect after 5,000 hr.
Asphaltic, or petroleum asphalt	Fails	No effect
Benzine, plus alcohol, plus gasoline	Fails	Fails

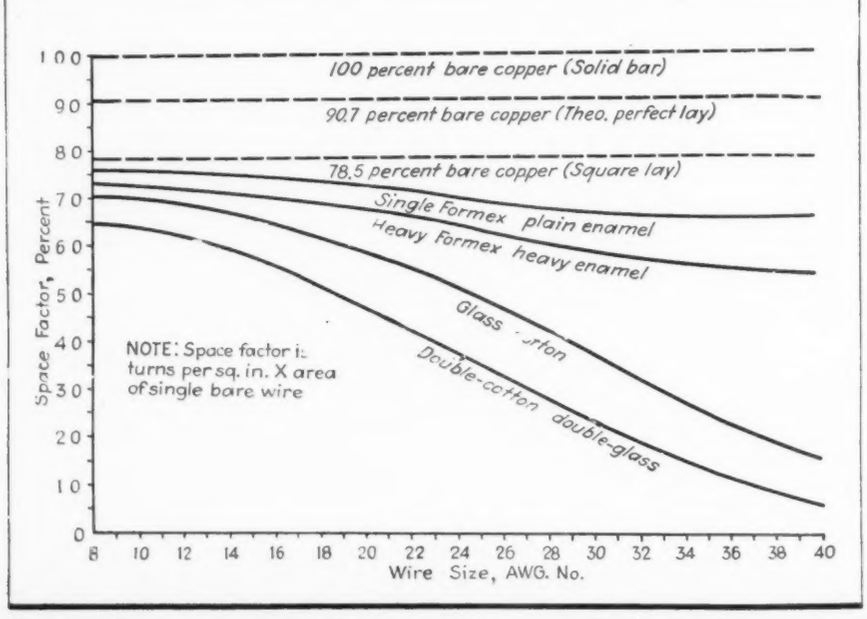


Fig. 1—Comparison of winding space factor on the basis of square lay.

Other Types

GLASS YARN INSULATED WIRE. Fiberglass yarn when wrapped on bare copper wire and given a subsequent varnish treatment to improve the abrasion resistance of the glass fibers, meets the requirements for A.I.E.E. Class *B* (not exceeding 150 deg. C.) insulating materials. The insulating of any magnet wire with a fibrous covering decreases its flexibility and makes it more difficult to wind into apparatus. Also the space factor is decreased.

FIBERS OTHER THAN GLASS. Fibrous materials such as cotton, silk, and nylon, are made into insulating yarns and wrapped on wire either bare or film coated. These materials all meet the A.I.E.E. Class *A* operating temperature of 105 deg. C. Wire insulated with such yarns are subject to the same sort of decrease in space factor as wire insulated with glass yarns. In certain applications, a yarn covering over film coated wire is desirable since the yarn affords a cushioning effect between the wires when they are wound into apparatus. No dielectric strength is added by the yarn insulation other than that gained by the mechanical separation of the conductors.

RECTANGULAR MAGNET WIRE. Round wire rolled to flat shapes and insulated with either a film coating, fibrous materials, or a combination of both, finds application in larger apparatus such as motor generator sets and the larger transformers. When high dielectric

strength is required, rectangular magnet wire is sometimes insulated with a ribbon of cellulose-acetate film. By use of proper winding methods high space factor can be obtained with rectangular wire.

SPECIAL MAGNET WIRE. Among special materials are the silicone resins and a material known as Teflon (poly tetrafluoroethylene). There is every reason to believe that the use of these materials will eventually produce excellent special application film coated magnet wire. A special application of color identification consists of bonding together in parallel, two strands of film coated magnet wire of different colors, thereby lowering winding costs.

Chromium-Vanadium Carburizing Steel

Abstract of "Chromium-Vanadium Carburizing Steels and Their Modifications" by F. F. Franklin and B. B. Beckwith in *The Vanadium Review*, Published by Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y.

CHROME - VANADIUM CARBURIZING STEELS develop excellent case and core properties in heat-treatment. They can be economically heat-treated by quenching directly from the carburizing pot because of their fine grain size and resistance to grain coarsening at elevated temperatures.

Table I—Specified Chemical Analysis Ranges for Chrome-Vanadium Carburizing Steel

	A.I.S.I. A. 6120	S.A.E. 6120
C	0.17–0.22	0.15–0.25
Mn	0.70–0.90	0.30–0.60
P	0.040 max	0.040 max.
S	0.040 max.	0.040 max.
S	0.20–0.35	0.15–0.30
Cr	0.70–0.90	0.80–1.10
V	0.10 min.	0.15 min.

The accepted analyses range for chrome-vanadium carburizing steel has been changed to produce a steel of greater hardenability without loss of strength and toughness. Table I lists analyses range of the new A.I.S.I. A-6120 and the former S.A.E. 6120 specifications.

Increasing the carbon content of chrome-vanadium steel increases the strength and hardness of the core and decreases its ductility and impact resistance. Increasing the chromium and manganese contents increases both the strength and ductility of the core. The impact resistance is increased by increased vanadium additions. Additions of vanadium up to 0.06 percent also increase the strength and ductility. Table II shows the physical property changes caused by changes in alloy content.

The presence of chromium and vanadium increase the speed of carbon penetration during carburizing and produce a low carbon gradient from case to core, reducing treatment strains.

Table II—Effects of Changes in Alloy Content on the Core Properties of Chrome-Vanadium Carburizing Steels

ANALYSES

Heat	C	Mn	Si	Cr	V
B	0.19	0.85	0.24	0.88	0.11
C	0.22	0.76	0.14	0.83	0.06
F	0.16	0.62	0.13	0.93	0.18
G	0.24	0.58	0.29	0.96	0.16
H	0.19	0.54	0.17	0.99	0.17
I	0.19	0.50	0.48	0.63	0.15

PHYSICAL PROPERTIES

Heat-treated as 1 in. dia. bars. Normalized 1725 deg. F.
Pseudo-carburized 16 hr. 1675 deg. F. Oil quench from Pot Tempered 350 deg. F.

Heat	Yield Point, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elongation in 2 in., percent	Reduction of Area, percent	Brinell Hardness	Izod Impact Resistance, ft. lb.
B	102,750	131,750	15.5	42.8	282	63–66
C	104,000	127,850	18	59.1	274	30–34
F	95,250	121,000	20	57.2	255	69–61
G	116,150	145,250	18	48.1	298	44–46
H	97,000	126,050	15	48.2	271	65
I	94,550	123,750	18	45.2	260	55

Pressure-Welding Stainless Steel Rings

From a paper presented by A. L. Rustay, Alan Crowell, and S. M. Jablonski, Wyman-Gordon Co. and C. J. Burch, Linde Air Products Co. at American Welding Society meeting, November 17-22, 1946, Atlantic City, N. J.

PRESSURE WELDING TECHNIQUES have been developed for the production of stainless steel rings of diameters up to 20 in. and in cross-sections ranging from 1½ to 4½ sq. in. Pressure welding is the most economical method of production of small quantities of rings of the stainless steels that are difficult to forge without cracking.

The welding technique consisted of joining two semi-circular halves by two diametrically opposite pressure welds. The faces of the ring halves are ground at an angle, as shown in Fig. 1, so that when pressure is applied the faces are in close contact. The heat, provided by oxyacetylene heating heads, and pressure are adjusted to give initial plastic flow at temperatures between 1,300 and 1,400 deg. F. Optimum heating and pressure cycles must be determined experimentally for different ring sizes and types of steel.

With satisfactory welding cycles, stainless steels can be welded into rings that can be subsequently reforged for additional forming. The physical properties of the welded areas will be equivalent to those of the parent metal. In properly welded joints, the joint strength is higher than that of the parent metal adjacent to it.

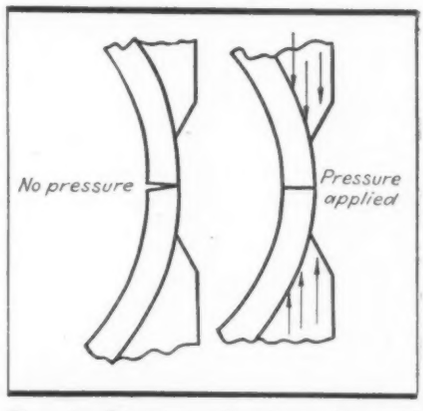
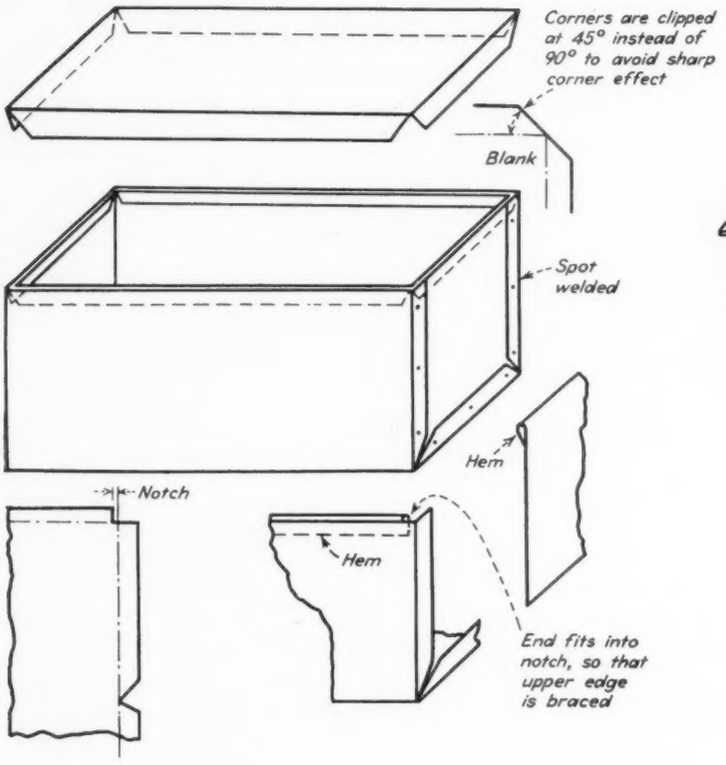
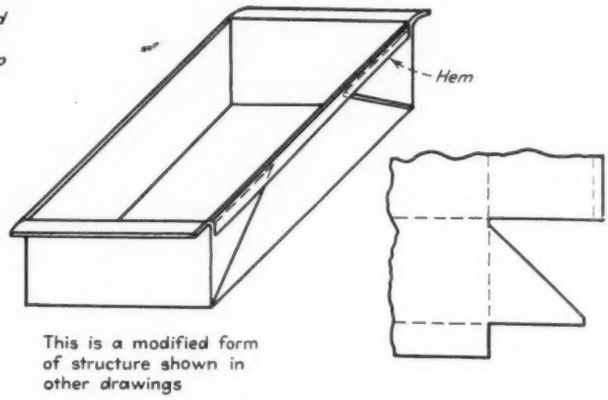


Fig. 1—Diagram showing effect of compensating grind.

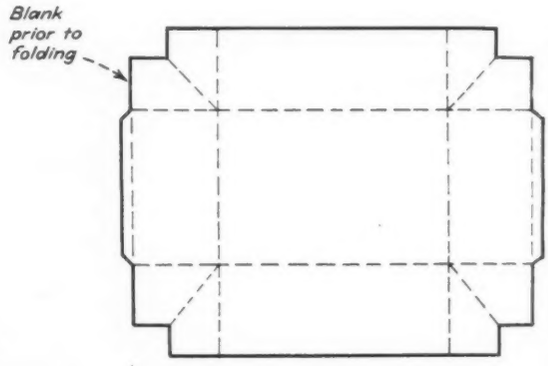
Design for Sheet Metal Boxes

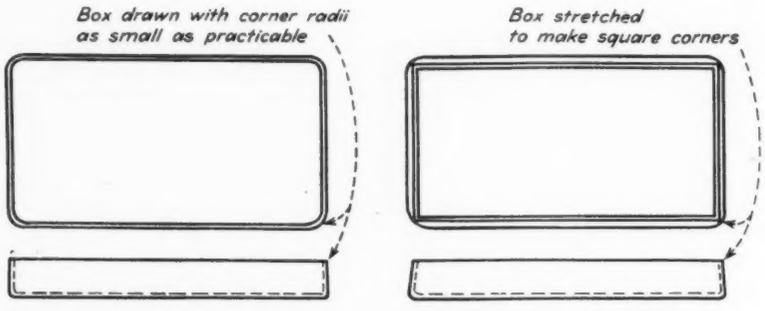

Corners are clipped at 45° instead of 90° to avoid sharp corner effect
Blank
Spot welded
Hem
Notch
Hem
End fits into notch, so that upper edge is braced



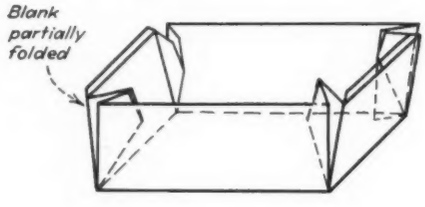
This is a modified form of structure shown in other drawings

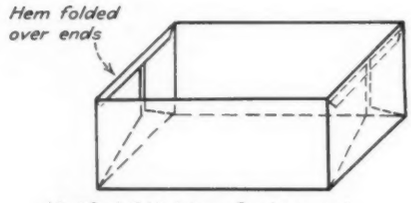
Tote Box for Heavy Tools





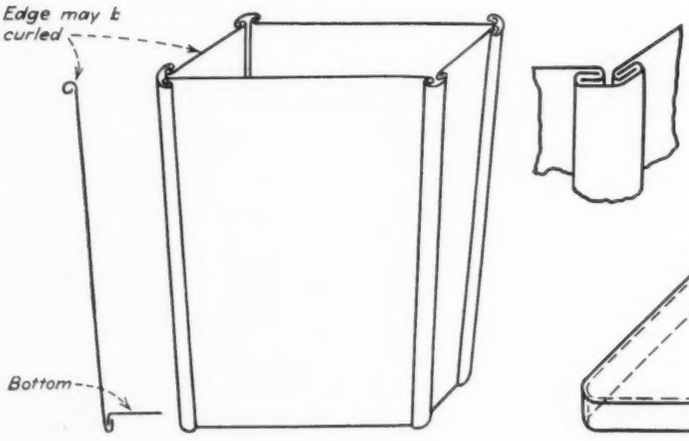
Drawn Box with Stretched Corners



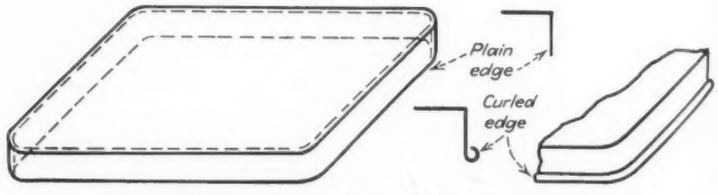


Modified folded type for improved appearance. Not leak-proof.

Box with Ends Folded on Inside



Waste Basket with Rounded Reinforced Corners



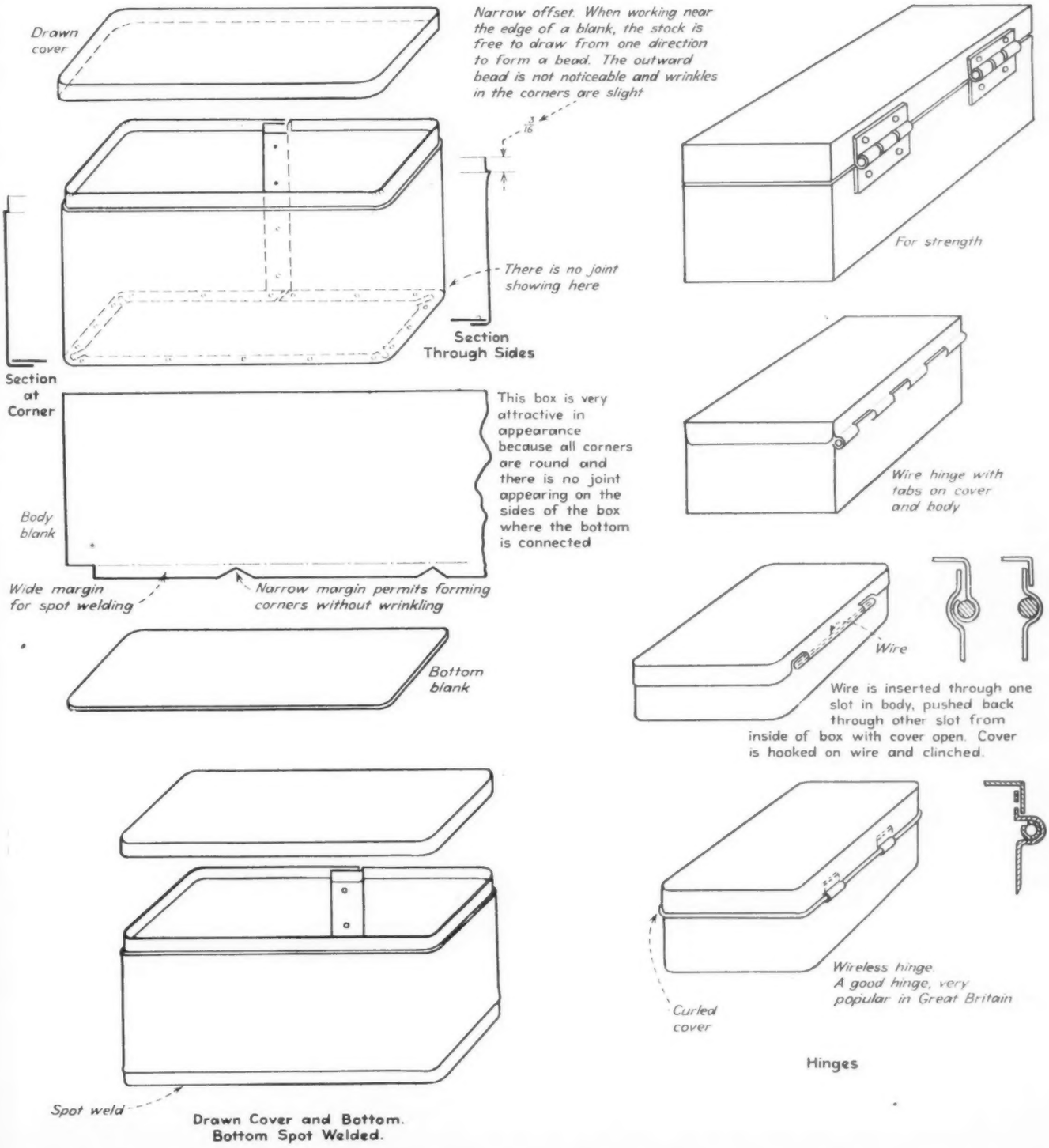
For round corner boxes, drawn shells may be used

Drawn Cover with Round Corners

With Square and Round Corners—III

WALLACE C. MILLS

Sheet metal boxes are designed for applications ranging from heavy-duty tool containers for industrial uses to very small and comparatively fragile affairs for medicines and the like. The designs presented herewith comprise the last in this current series.


Drawn cover
Narrow offset. When working near the edge of a blank, the stock is free to draw from one direction to form a bead. The outward bead is not noticeable and wrinkles in the corners are slight
There is no joint showing here
Section Through Sides
Section at Corner
This box is very attractive in appearance because all corners are round and there is no joint appearing on the sides of the box where the bottom is connected
Body blank
Wide margin for spot welding
Narrow margin permits forming corners without wrinkling
Bottom blank
Spot weld
Drawn Cover and Bottom. Bottom Spot Welded.
For strength
Wire hinge with tabs on cover and body
Wire
Wire is inserted through one slot in body, pushed back through other slot from inside of box with cover open. Cover is hooked on wire and clinched.
Wireless hinge. A good hinge, very popular in Great Britain
Curled cover
Hinges

INTEGRAL HP. SINGLE-PHASE MOTORS

Their Characteristics and Uses

M. E. CUTTEN
Induction Motor Division, General Electric Company

How, when, and where to use single-phase 1 to 10 hp. motors, including basic steps in matching machine and motor characteristics. Different types of motors are explained and discussed such as the capacitor, repulsion-start, repulsion-induction, permanent split-phase capacitor and the straight repulsion motor.

SINGLE-PHASE integral hp. motors are increasingly powering medium sized home freezers, heat pumps, air or refrigeration compressors, ventilating fans and water pumps. This is because practically all major markets such as homes, retail stores, markets, garages, filling stations and farms usually have a single-phase power circuit so at time of installation power supply is never a problem.

Application Fundamentals

In selecting an integral hp. motor for a particular product the designer must find answers to three questions: (1) Will the motor start the load and bring it to the required speed?, (2) will the motor carry the load successfully and continuously during the operating time?, (3) will the motor be a dependable source of power throughout the life of the equipment?

The performance of a motor is usually shown by the speed-torque relationship. As the typical speed-torque curve for a fan in Fig. 1 shows, it takes about 1½ to 3½ lb. ft. torque to overcome the friction in the bearings and start the fan. As the torque requirements decrease, the fan accelerates along its characteristic curve to a normal operating speed requiring 3 lb. ft. torque. Applying the right motor is simply matching the speed-torque curve of a motor to that of the fan.

To operate this fan at full load and full speed continuously, for example, will require a motor rated one hp. at approximately 1,800 r.p.m. and a speed-torque curve as shown in Fig. 2. Torque is the ability to pull the load; horsepower is the ability to keep the load going continuously while dissipating the losses.

When matching the motor and fan speed-torque curves the three points *A*, *B*, and *C* shown in Fig. 3 are significant. Point *A* shows that there is sufficient starting-torque. Shaded area *B* is the available torque remaining to accelerate the load, and is, in this instance, sufficient. Point *C*, the intersection of the motor and fan characteristic at the desired operating speed shows a point of stable operation. So this motor will drive the fan satisfactorily. By a similar process of matching single-phase motor characteristics to load requirements any product can be correctly motorized.

General Purpose Motors

With the exception of a few repulsion motors for special purposes, integral-horsepower single-phase motors are induction motors. The single-phase induction motor has the basic torque characteristic shown in Fig. 4. The motor has no starting torque and like a boat's outboard engine has to be spun to get it started.

Starting the motor and bringing it and the load up to operating speed is done by an auxiliary starting circuit within the motor. As shown in Fig. 5, the auxiliary circuit adds the necessary starting torque component to the basic speed-torque curve of the motor.

This component can be supplied by: (1) Producing the equivalent of a rotating field by phase displacement in the stator with an auxiliary capacitor circuit, or (2) using the repulsion principle with a wound armature and off-neutral brush setting on a commutator. With either scheme a speed sensitive device disconnects the auxiliary circuit when the motor is near operating speed. As shown in Fig. 6, the completed curve approximates the speed-torque curve of the polyphase induction motor with its smooth acceleration.

THE CAPACITOR MOTOR. The capacitor-start induction motor has iron, copper, and capacitance combined in right proportions to get the best balance of motor characteristics. The stator is wound with a main and an auxiliary circuit, similar to the phase windings of a two-phase induction motor. The main winding is connected directly to the single-phase line. The auxiliary winding is connected in series with a capacitor and switch as shown in Fig. 7. The capacitor in the circuit delays the current in the auxiliary winding, so that the maximum flux in the auxiliary circuit lags the maximum flux in the main winding by 90 deg. producing an effective rotating field. The motor operates like a two-phase induction motor during the starting and accelerating period. At about two-thirds full-load speed, the switch disconnects the auxiliary circuit and the motor continues to accelerate and run as a single-phase induction motor.

By varying the ratios of iron, copper, and capacitance in this basic circuit the speed-torque characteristics, efficiency, power-factor, and starting current can be altered to a much greater degree than in repul-

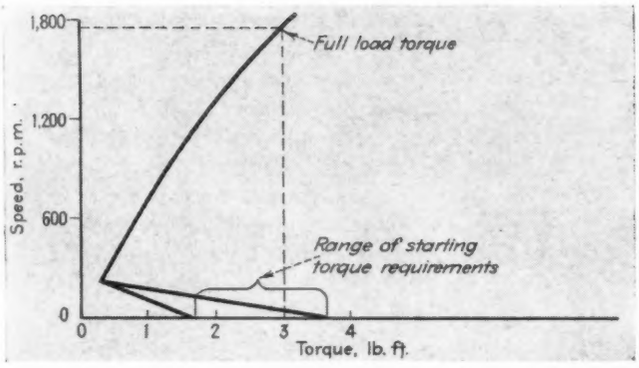


Fig. 1—Speed-torque characteristic for a fan showing range of starting and running torque at normal speed.

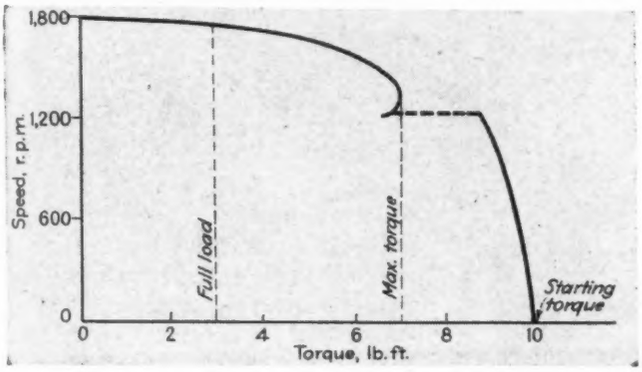


Fig. 2—Speed-torque curve for 1 hp. 1,800 r.p.m. motor showing the starting and operating characteristic.

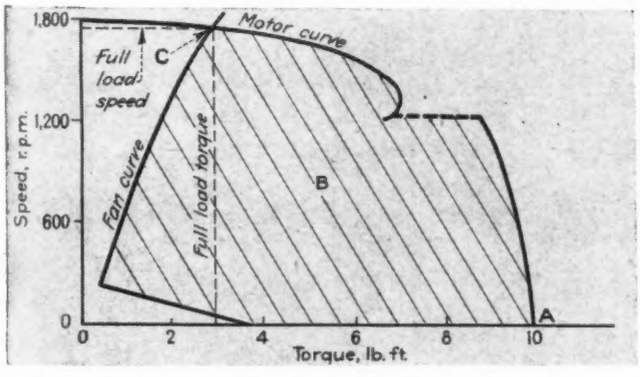


Fig. 3—Motor operating characteristic meet load requirements of fan, as shown by points and area *A*, *B*, and *C*.

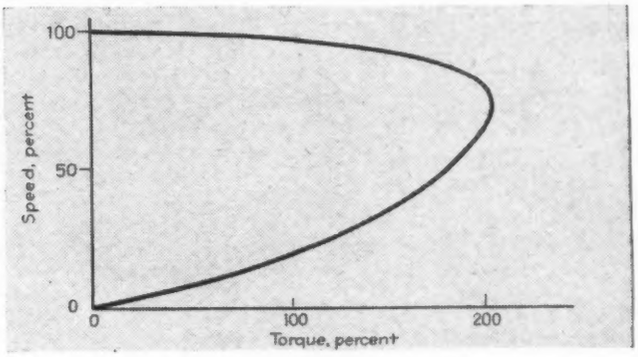


Fig. 4—The inherent speed-torque characteristic of a single-phase induction motor has zero starting torque.

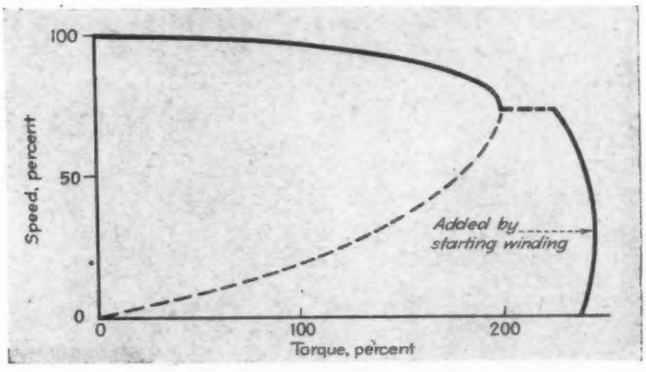


Fig. 5—An auxiliary circuit gives the necessary starting component to the single-phase induction motor curve.

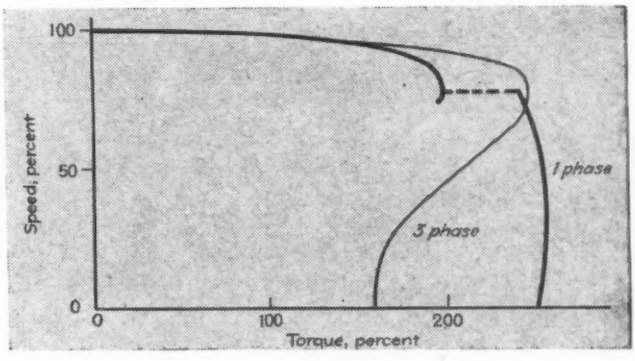


Fig. 6—The curve of a self-starting single-phase motor is similar to that of a three-phase induction motor.

sion-start motors where the characteristics are inherently more fixed. For example, in addition to the basic use of the capacitor for phase displacement in the starting circuit, it can be used also in the main running circuit to improve efficiency or to raise the maximum torque without a proportional increase in the starting current. As a result of this flexibility in design, two types of capacitor motors in industrial use are the normal-starting-torque and the high-starting-torque motors.

The normal-starting-torque motor has sufficient torque to start and accelerate ordinary loads such as centrifugal pumps, fans, blowers, and wood-working machines. This motor combines well balanced torque characteristics with simple design and reasonable values of starting current. The high-starting-torque motors are used on applications such as reciprocating compressors, reciprocating pumps, and loaded conveyor belts that are often considered general purpose applications but that require a higher starting-torque. The high-starting-torque motor has the same reliability as the normal-starting-torque motor but frequently requires the addition

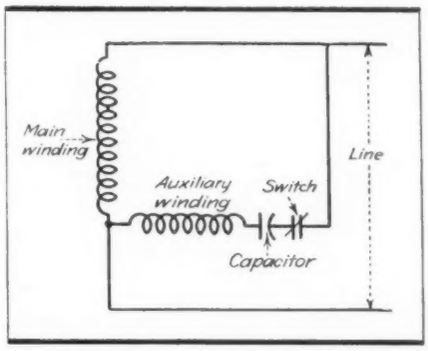


Fig. 7—In a capacitor-start motor, the auxiliary winding, capacitor, and starting switch are connected in series giving two-phase starting.

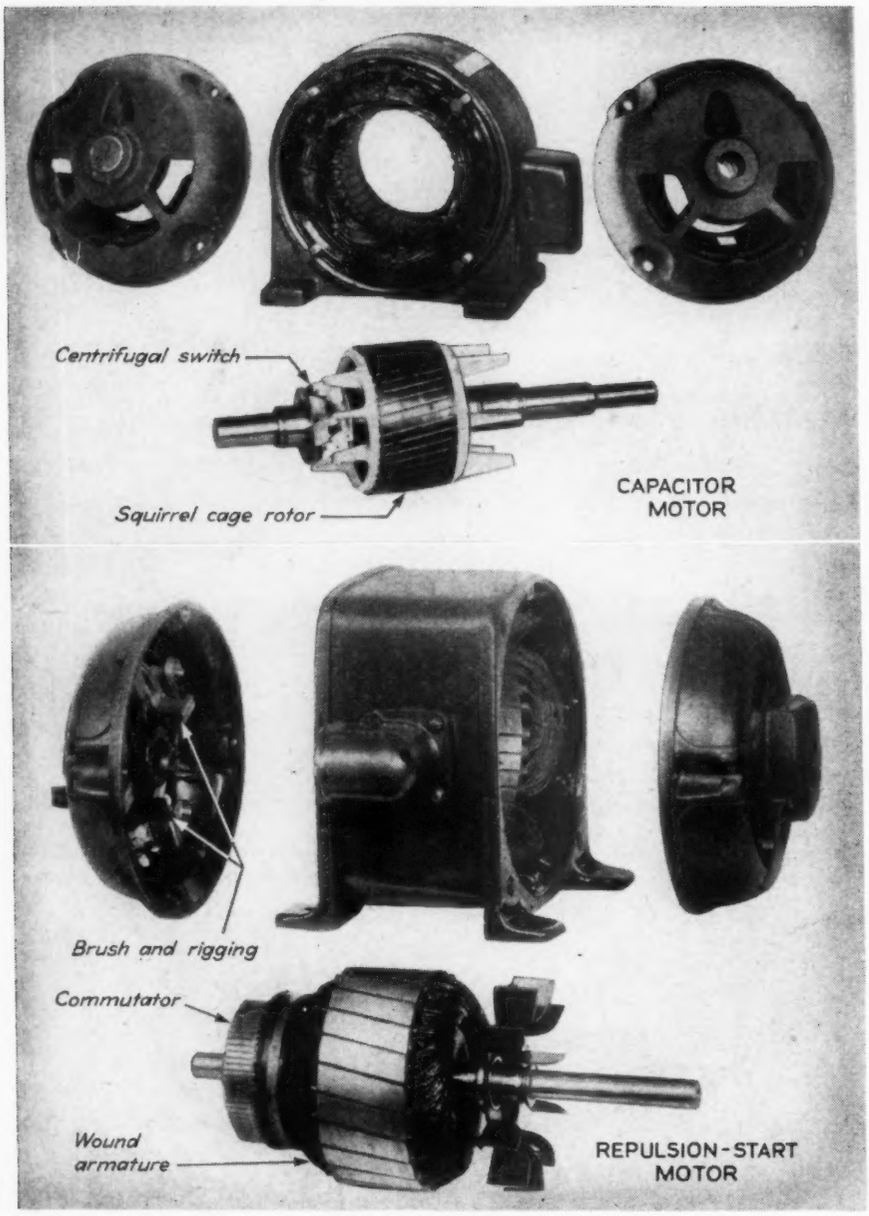


Fig. 8—The capacitor-start motor is simpler mechanically and has fewer moving parts than the repulsion-start motor. Maintenance is less costly.

of running capacitors to obtain the required values of maximum-torque at the same reasonable starting-currents. The normal-starting-torque motor should be used wherever possible. If the high-starting-torque motor is applied where it is not really needed the excessive torque may accelerate pumps and fans too rapidly, causing unnecessary noise and excessive wear.

The mechanical construction of the capacitor-start motor is simpler than that of the repulsion-start motor. Commutator, brushes, and brush rigging are not required and the frequently used complicated mechanism for lifting the brushes after starting is replaced by a relatively simple centrifugal switch. A simple cast aluminum squirrel-cage rotor winding is used instead of the insulated rotor winding necessary in the repulsion-start motor. The capacitor motor has fewer moving parts as shown in Fig. 8, thereby reducing mechanical wear and maintenance. These factors are important in many machines.

The capacitor motor is economical up to 5 hp. at 3,600 r.p.m. In larger sizes, the size and cost of the capacitors for good running characteristics are too large, and repulsion-start induction-run and repulsion-induction motors are used for such applications.

REPULSION-START MOTOR. In repulsion-start induction-run motors, the proportions of iron and copper are the only variables in design. The stator of the motor is wound with only a main single-phase winding. Starting torque is produced by a drum-wound rotor circuit connected to a commutator. During starting, a pair of short circuited brushes rest on the commutator. Since they are set about 20 deg. off the axis of the main field, as shown in Fig. 9, a current flows in the rotor that reacts with the field and produces starting torque. When the motor has accelerated to about two-thirds of full-load speed, a centrifugally operated mechanism lifts the brushes off of the commutator and short circuits the commutator bars. The motor then runs as an induction motor.

These motors have higher starting torques than capacitor motors, but for the same current the capacitor motor has equivalent pull-up and maximum torques. The starting and running characteristics of repulsion-

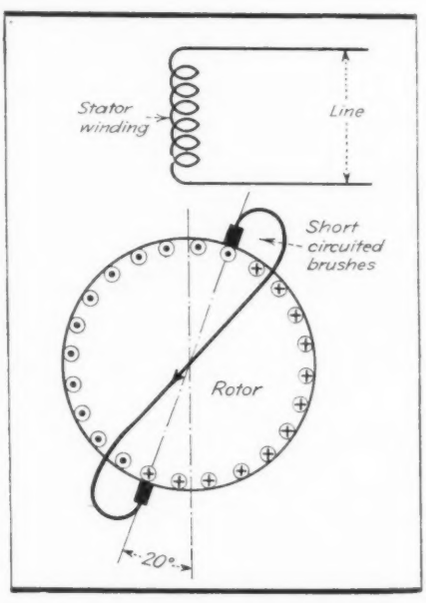


Fig. 9—In repulsion type single-phase motors, short circuited brushes are set off of neutral to produce starting.

start motors are adequate to drive most loads, and they are suitable for pumps, compressors, and machine tools. Electrical and mechanical noise, and extra maintenance because of brushes and commutators are disadvantages. When noise, or the accessibility of the motor are important

factors, a capacitor motor is usually preferable. The repulsion-start induction-run motor and the repulsion-induction motor are applied up to 10 hp. at 1,800 r.p.m., but from 5 to 10 hp. are usually the best sizes to use.

Repulsion-Induction Motor. The repulsion-induction motor differs from the repulsion-start induction-run motor because it operates as a combination repulsion and induction motor. At starting, the repulsion winding supplies most of the torque but as the speed increases the squirrel-cage induction winding becomes predominant. The repulsion winding remains in the circuit during running and the brushes carry current continuously. The commutator is not short-circuited nor are the brushes lifted during the operation of the motor. No mechanism is needed to disconnect the starting circuit before operating speed is reached as is required in induction-run motors. The speed-torque curve is smooth without a break at a transfer speed. This is a distinct advantage in applications where a critical point in the acceleration of a load occurs at the transfer speed.

Although the actual torque available for acceleration is less in the repulsion-induction motor than in some capacitor start motors, the ability to withstand long accelerating periods is greater. This ability plus the unbroken speed-torque characteristic make the repulsion-induction motor suitable for certain high inertia loads, such as those encountered in laundry extractors, where other types of motors have been less satisfactory.

Brush noise is continuous on this motor. The motor sometimes produces radio interference. Relatively, maintenance is greater on these motors because the brushes and commutator are in the circuit all the time.

Special Purpose Motors

Products designed to use a general purpose standard motors without sacrificing other features will always be lower in cost. For a slightly higher cost, special electrical and mechanical modifications of standard motors may be desirable for unusual applications. Some of these special motors drive close-coupled pumps, hoists, jet-pumps, valves, and reversing machine tools.

In addition to the modifications of standard motors, two other types for special applications are the permanent split-phase capacitor motor, and the repulsion motor.

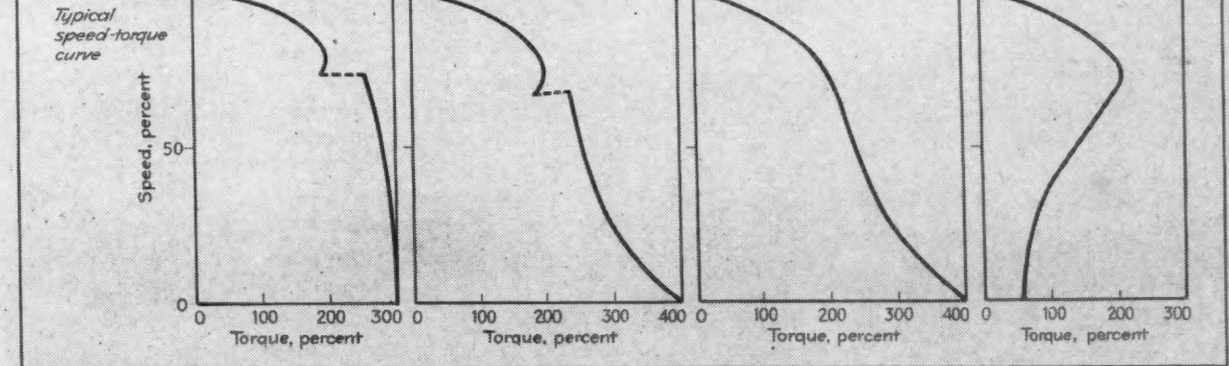
Permanent Split-Phase Capacitor Motor. The permanent split-phase motor in integral horsepower sizes is often used to drive slow speed direct-connected fans.

This motor behaves like a two-phase induction motor with low starting torque, has a smooth unbroken speed-torque curve and is almost as simple as the polyphase induction motor. The stator is wound like a two-phase motor. The capacitor is connected in series with one of the phase windings to obtain phase displacement and produce the necessary revolving field. No brushes, commutator, or centrifugal mechanism and switch are required. Maintenance is less than with any other single-phase motor.

The permanent split-phase motor has better than average values of maximum torque and is a superior single-phase motor for momentary overloads. In spite of the many advantages of the permanent split-phase motor, its relatively low starting torque of about 30 percent has greatly limited its use. Without a clutch arrangement, this motor will reliably start and accelerate only a relatively small friction load.

For direct connected fans, definite advantages include extreme quietness and two speed or adjustable speed operation merely by changing the volt-

COMPARISON OF FOUR TYPES OF INTEGRAL HP SINGLE-PHASE MOTORS



Motor	Capacitor-start Induction-run	Repulsion-start Induction-run	Repulsion Induction	Permanent-split Capacitor
Standard ratings (Dripproof and totally inclosed)	1 to 3 hp., 115/230 volt, 1,800 r.p.m.	1 to 10 hp., 115/230 volt, 1,800 r.p.m.	5 to 10 hp., 230 volt, 1,800 r.p.m.	1 to 3 hp., 115/230 volt, 1,800 r.p.m.
Typical applications	Compressors, pumps, fans, machine tools	Compressors, pumps fans, machine tools	Compressors, pumps fans, machine tools	Fans, saws
Principal advantages	Quiet operating No radio interference Low maintenance	High starting-torque Low starting current	Lowest starting-current High starting torque Unbroken acceleration	Minimum mechanical parts Low maintenance High maximum torque
Disadvantages (Depends on quality of design)	Higher starting current	Low pull-up torque Starting noise High maintenance	Radio interference High maintenance	Low starting torque

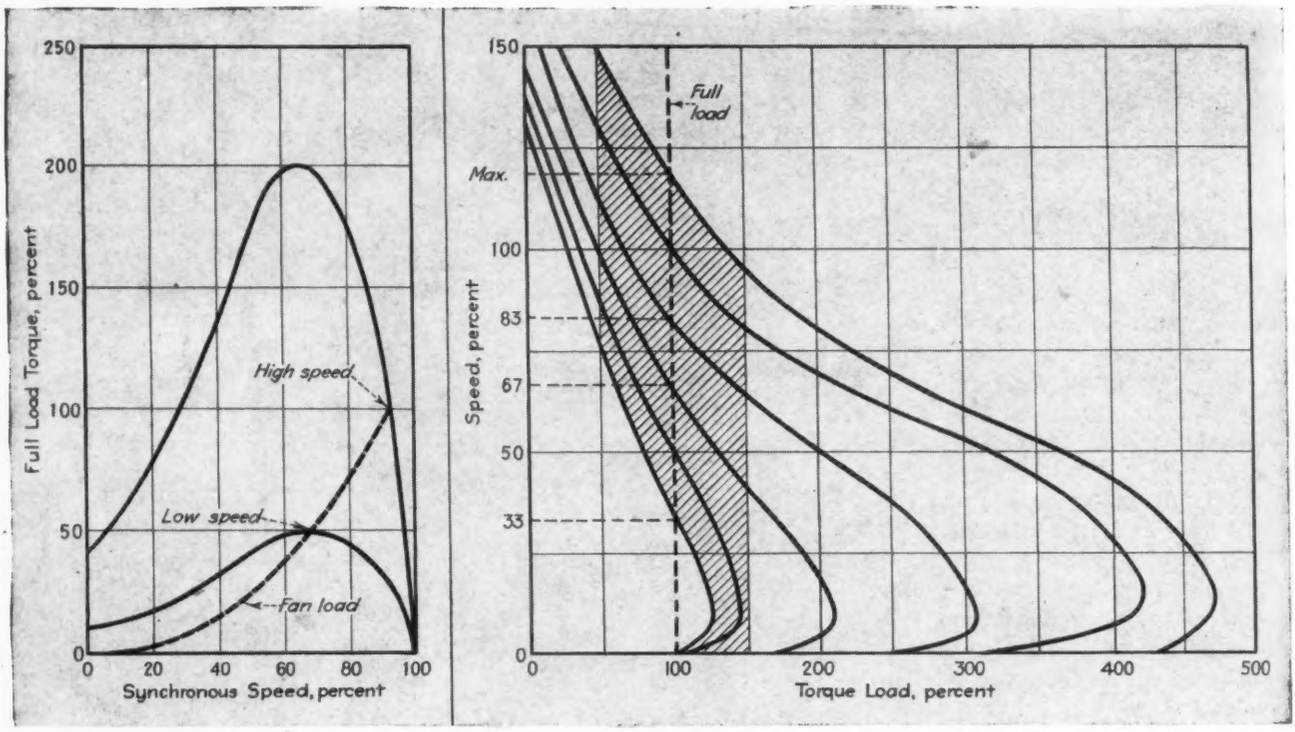


Fig. 10—Operating characteristics of permanent split-phase capacitor motor for two-speed operation. Fig. 11—Changing position of brushes on a repulsion motor gives a family of good speed-torque operating characteristics.

age applied to the motor. In Fig. 10 is shown typical two-speed operation.

The high maximum torque of this motor makes it potentially useful where heavy momentary overloads are frequent, for example, with floor sanders and grinders when the operator bears down hard on the work only high maximum torque will keep the motor from stalling. The motor has much promise for such applications if future development improves the starting-torque characteristic.

REPULSION MOTOR. The repulsion motor uses the repulsion principle for both starting and running. It has the speed-torque characteristics of a series motor, with speed increasing as torque decreases. Unlike the induction motor, it has no limiting synchronous speed. Therefore its no-load speed is high, and over parts of the operating curve slight changes in torque result in big changes in speed.

The most useful feature of the repulsion motor is speed control. By changing the position of the brushes on the commutator a family of speed-torque characteristics are obtained, one for each setting of the brushes as shown in Fig. 11. When applied to a constant-torque load this gives wide speed control. Machines that require constant tension over a range of speeds such as cable reels, often use the repulsion motor. The ease of speed control is an advantage in driving the relatively constant-torque load of printing presses. Because of its high no-load speed, the motor is used for testing automotive and aircraft engine magnetos. The load test is taken at rated torque, and the overspeed test at no-load.

When only single-phase power is available for sizeable motorized equipment, the different types of motors discussed will give good service, and permit the designer reasonable flexibility in designing electrically driven machines and appliances. In rural areas and for the home and small commercial establishments, usually only single-phase power is readily available. But at best, the single-phase motor does take more material to give characteristics comparable to those of the polyphase induction motor, and an extra circuit inside the motor is needed to get it started. Therefore it is preferable to use a polyphase induction motor when polyphase power is available or readily obtainable.

Many applications can best use standard designs of single-phase motors housed in standard inclosures, such as: Open, splashproof, totally inclosed, totally inclosed fan-cooled, and explosion-proof. When a product requires a special design, integral-horsepower single-phase motors usually can be designed to meet the unusual conditions.

* * * *

SOME TWO HUNDRED YEARS AGO, the citizens of a small town in England were greatly alarmed because an abandoned well in the neighborhood gave off an obnoxious odor. A clergyman in the neighborhood became interested and found that when he held a lighted taper over the well, the vapor or gas burst into flame. He began to make experiments to see if he could obtain this gas artificially. He built a small furnace which was completely inclosed except for a small outlet. This he filled with soft coal and set on fire. He found that a gas similar to that which came from the old well was issuing from the outlet and when touched with a match, burst into flame. He continued his experiment by piping this gas into other parts of his house and it became the talk of the village. The attention of the Royal Society was finally attracted and in 1739 this man, John Clayton, gave a lecture on its value as an illuminant. He was the first recorded user of coal gas.

Common Industrial Electroplates—II

Nonferrous Base Metals

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Application and limitations of different plates for nonferrous base metals, such as copper, brass, and bronze. Discussion includes plating with such metals as tin, nickel, and silver; use of plating on zinc die castings and aluminum parts; and summary of general plating practice by an excellent application chart.

IN ADDITION to the ferrous base metals discussed in Part I of this article in PRODUCT ENGINEERING, March 1947, page 139, the nonferrous base metals pose a different set of plating problems for designers.

The largest family of nonferrous materials requiring plating is the copper bearing materials including pure copper, brass, or bronze. Copper is a beautiful bright red metal that can be buffed to a high luster. But it is readily attacked by oxygen, sulphur compounds or other contamination, and tarnishes in a few hours even in a cool dry atmosphere. The tarnish may be alkaline or acidic in nature. In either event, an extremely thin coating of corrosion seems to seal the surface and prevent or retard further corrosion.

Thus copper and its alloys are used for cooking utensils and to pipe drinking water and foods, but not for storing foods or potable liquids.

Copper, Brass, and Bronze

Copper can be readily plated with tin, nickel, silver, or gold. Zinc should never be used. It can serve no useful purpose on the surface, and is absorbed or dissolved into the copper even at room temperature. Whereas both zinc and copper are soft and somewhat malleable, a high zinc alloy is hard, brittle, friable, and has low strength. This means definite uncontrollable deterioration of copper bearing surfaces in contact with zinc.

The same is true, but to a less extent and at a much lower rate, for cadmium on copper. There is one exception that has wide commercial use for a special application. Aluminum and its alloys will preferentially decompose where a copper to aluminum galvanic couple is formed. The reaction between aluminum and cadmium is comparatively slow. Where copper or its alloys are to come in contact with aluminum or its alloys, as often occurs in aeroplane designs, it is recommended practice to plate the copper bearing part with cadmium, so that the joint from either metal is to cadmium, and not copper to aluminum.

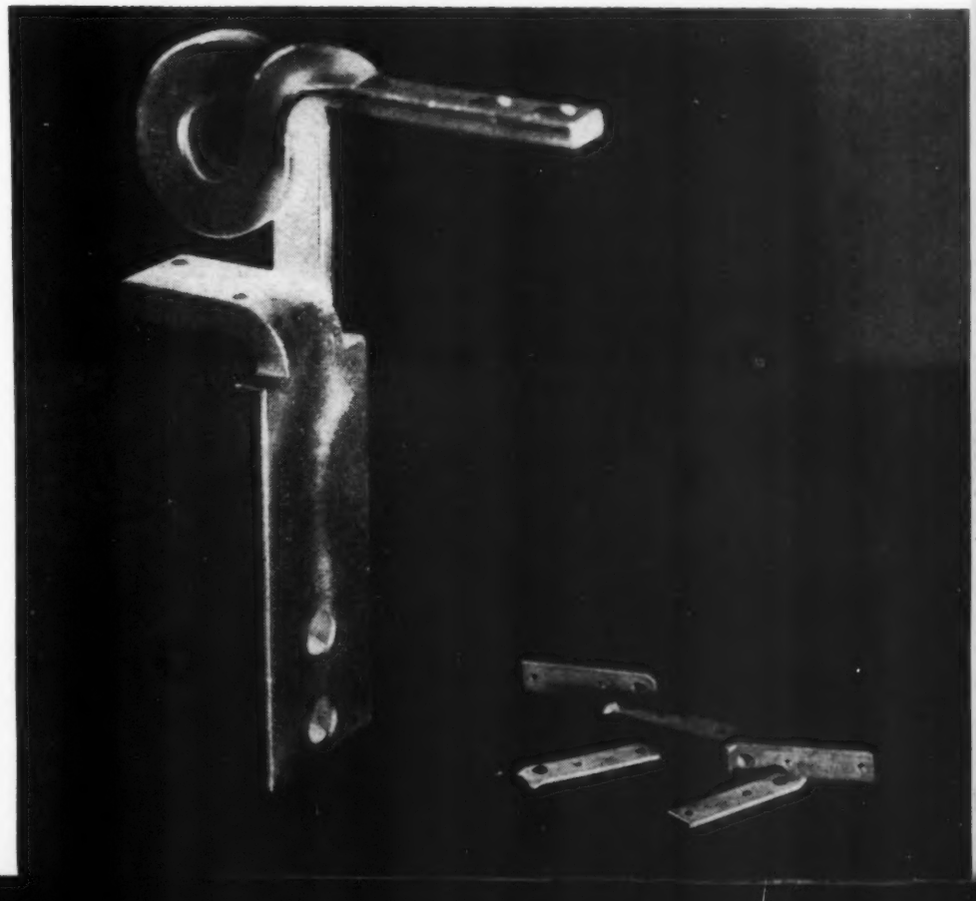
Tin is used for plating articles for food handling and storage, and for electrical apparatus.

Nickel is used also to plate food handling equipment, plumbing supplies, for other decorative purposes, and as a base for decorative chrome.

Chromium can be plated directly to copper and many of its alloys. The extra operations for nickelplating copper or its alloys over copper plate before chromium plating are usually justified.

Brass is a zinc-copper alloy. Bronze is a tin-copper alloy. Often small amounts of other materials are added and used in the name to denote the type, as aluminum bronze and manganese bronze. These alloys are made for economy or to improve working or physical characteristics. The higher copper alloys can usually be

Silver plate enhances electrical conductivity on these circuit breaker parts.



plated the same as copper. As the content of zinc or tin increases it becomes desirable and sometimes necessary to plate with copper first, and then apply other plates as desired. Where two or more pieces are soldered or brazed together it is necessary to deposit a good copper plate if the joint is to be completely hidden and good durability obtained.

Brass plating, where zinc and copper are deposited in controlled proportions, has many adherents. So far, its only large use is in small electrical appliances for homes. Here it is applied to the base metal under the nickel or nickel-chrome plates, and, in some few instances, under silver deposits. Users justify its use because of low polishing cost and ability to buff to a high luster. Since it is practicable to provide bright copper, nickel and chrome deposits, brass plating for this purpose may become obsolete.

Zinc Die Castings

Where plating is applied to zinc die castings it is usually done for decoration. From a theoretical standpoint such plating is simple, but in practice it is difficult. All that is required is to strike the surface with copper from a cyanide type copper solution, then build up a good copper deposit followed by the desired top plates. Practically, good durable articles are extremely hard to produce. Die castings are often characterized by a discontinuous, extremely thin, relatively hard surface supported by a soft spongy interior body with many voids, discontinuities and often excessive contamination. Most of the contamination comes from the reprehensible habit of using oils, dopes or homemade melanges to coat the die, to try to overcome the deficiencies of the present condition of the die, poor design, or poor casting practice. This seldom works but the practice continues.

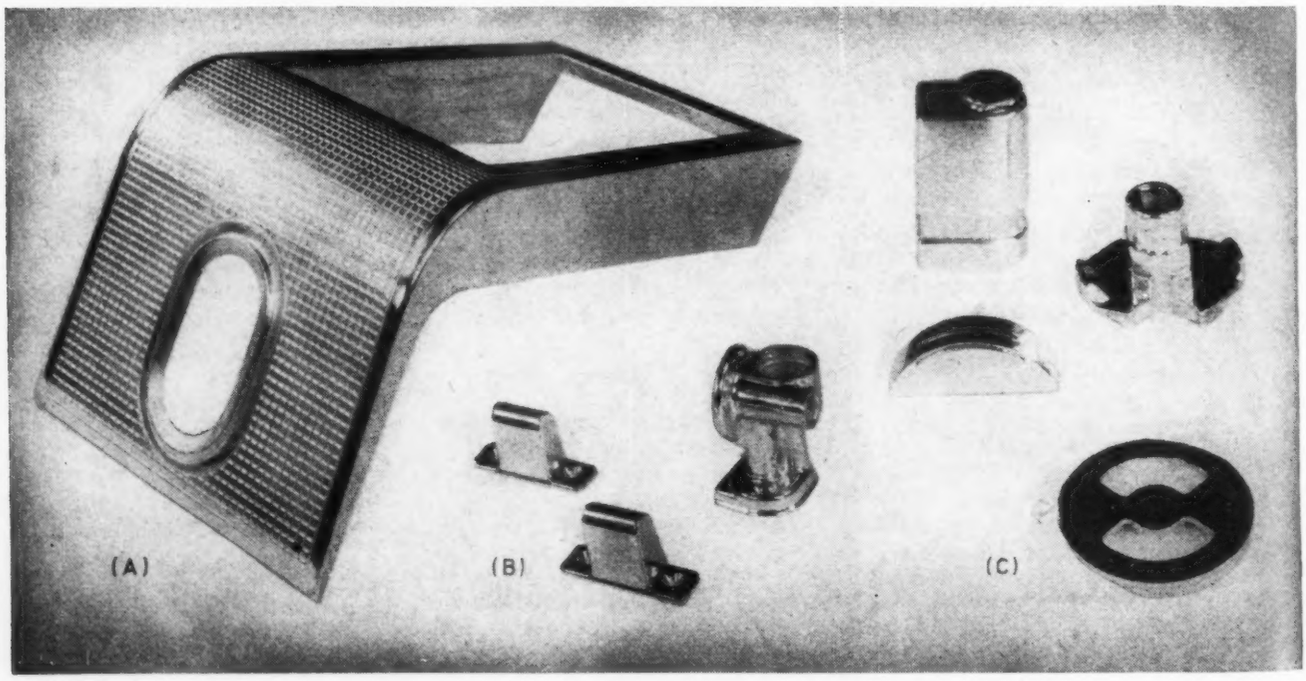
Good zinc die castings require no polishing. They are easily buffed to a high luster without cutting through the skin. Not less than 0.001 in. combined thickness of copper and nickel will give satisfactory nonblistering or peeling life for from three to five years or longer. This thickness is used on such surfaces as automobile hardware exposed to the elements, or on refrigerator and air conditioning hardware exposed to indoor cyclic temperatures and condensation. Where the expense is justified, heavier plates up to 0.002 in. have been considered.

One of the principal difficulties is the absorption of zinc into the copper at the plate interface. Using not less than 0.0005 in. copper suffices for normal life. Some few parts known to have not over 0.0003 to 0.000 35 in. of copper are satisfactory after 10 to 12 years of service. Even heavier copper and nickel are better where possible.

No porous or overpolished surface will stand up regardless of the method of plating or the thickness of plate. A poor surface will absorb the cleaning and plating chemicals. These will inevitably cause internal corrosion and short time failure. When using zinc die castings for long-life surfaces, provision should be made for buffing, inspection and test, in the die casting department, so that only good castings that can be protected and beautified are sent to the plater. Certainly the plater should be relieved of unfair charges of poor plating. No doubt, some poor plating has been done. But the dependable quality plater now forced to plate on surfaces that make satisfactory work impossible, should not have to accept charges of poor workmanship or risk his reputation.

Aluminum

The usual plating department does little with aluminum. Many small and even large parts are cleaned and



Plated zinc die castings. (A) Large frame with decorative copper nickel chrome plate. (B) Latch strikes for refrigerator and fan gear case plated with copper, nickel, and chromium for protection and appearance. (C) Three small parts for water cooler bubbler valve are bronze castings with high luster nickel and chrome finish. Bubbler has satin finish.

Suggested Industrial Uses and Limitations for Common Electroplates

NOTE: As engineering information this chart is open to argument, criticism, and disagreement. Each article plated has its own particular function and abuse in its final environment, which is the basis used to analyze a situation and recommend a plated finish.

Base Metal	Electroplated Metal	Effective Thickness in.*	Commercial Practice		Remarks
			Thickness, in.	Type of Application	
Steel	Zinc or cadmium	0.00035	0.00005 to 0.0010	For protection only, where appearance is not important.	Chromate treatment increases protection many fold when it remains in place. Of little value where it is dissolved and washed away.
	Zinc or cadmium chromate treated	0.00035	usual is 0.0003 best is 0.0006		
	Hard chrome	0.0008+	0.00005 to 0.0003 0.00015 to 0.0006 0.0005 to 0.006+	Cutting edged tools Gages, sliding surfaces, etc. Dies, wearing surfaces, etc.	Effective on steel not under 48 nor over 60 Rockwell C. If steel is softer, chromium fractures. If steel is harder, steel fractures.
	Nickel or Nickel-chrome	0.0004	0.0001 to 0.0005	Kitchenware and low cost hardware.	Decorative chrome is not over 0.0000025 in. thick. Satisfactory if cleaned after use and stored.
	Copper-nickel or copper-nickel chrome	0.0003 Cu 0.0004 Ni	Copper Strike Nickel 0.0002	Low cost, low protection.	Decorative, good indoor dry only.
			Copper 0.0002 Nickel 0.0002	Low cost, low protection.	Decorative, good indoor dry only.
			Copper 0.0003 Nickel 0.0004	Low cost, good protection.	Decorative and protective, light service outdoor.
			Copper plus Ni. 0.001	Medium, very good protection.	Decorative and protective, good, severe humidity.
			Copper plus Ni. 0.002	High cost, best protection.	Decorative and protective, very good in severe humidity.
	Copper-silver (or Gold)	0.0003 Cu.	Special. Varies from 2 flash color plates up to many thousandths thick. Best method: Specify copper thickness; specify noble metal by weight for each particular part.		
	Tin	0.00025	0.00015 to 0.0005	Special for mild acid foods	Protects food from iron; not iron from elements.
	Bright alloy of copper, tin and zinc	0.0002	0.0001 to 0.0002	Substitute for nickel	More brittle but more corrosion resistant than nickel of same thickness. Buffing usually not required.
	Brass	0.00035	0.0001 to 0.0010	Substitute for copper	Buffs easier. Tarnishes less. Harder to control.
Copper	All above except zinc-cadmium and hard chrome	as above	as above	as above	Copper plates are omitted on copper unless soldered or brazed joints occur. Tin should never be less than 0.00035 in. on copper for humidity protection.
	Cadmium	0.00035	0.00035 to 0.002	Special: Only on copper articles which will contact aluminum.	
Brass Bronze Zinc die castings	Copper plate then plate as copper parts	as above	as above	Copper may be omitted on high copper alloys.	
		0.0010 combined	Same as high grade copper nickel on steel	Not less than 0.0003 in. copper, 0.0004 in. nickel with total combined plate not less than 0.001 in. are required for nominal protection from elements for 3 to 5 years.	
Aluminum	1. Anodize, reduces, nickel plate, finish plate, or 2. Chemical zinc plate, zinc or copper plate, finish plate. Special applications only. No data on endurance.				

*Minimum for effective corrosion resistance in normal weather 40 deg. N. Lat. for 3 to 5 years.

passivated. The passivating may be simply a clean, or it may be a cleaning and etching operation followed by a cold or hot oxidizing acid (usually nitric) to give a thin aluminum oxide surface. Better passivation, durability, and appearance is obtained by electro-anodizing. Chromic or sulphuric acid d.c. treatments with the work as the anode give best results although other methods are used.

Normal electroplating on aluminum is an unknown art at present. But because of a continuous and ever increasing demand, several more-or-less satisfactory ways of superimposing a coating over aluminum have been developed and usefully employed. One way is to anodize the surface, then partially reduce the oxide film to a predetermined amount as shown by the gassing. The part then is immediately plated in a nickel plating solution, such that a satisfactory strong adherent black nickel is plated, until the oxygen in the remainder of the aluminum oxide has been reduced to nickel oxide. Then the bath continues to plate white metallic nickel to the desired thickness. No experience with this type of deposit is available for this article.

Another satisfactory method is to obtain an adherent electrochemical substitution deposit of some other metal. Methods of depositing zinc

have been successful. Electrodeposits of zinc or copper, followed by any desired top surface can be made on this. Many gold and silver plated parts were successfully made by this method for secret war instruments.

General Plating Status

In general the major construction materials such as iron, copper, zinc and aluminum and their alloys, can be plated to give improved appearance or protection from their environment. Almost any desired final deposit and appearance can be obtained by using proper preparatory methods or intermediate deposits.

There are two dissimilar types of protection. The one, without regard to beauty, sacrifices the protective plate to use up the contaminating influence. It usually provides the lowest cost and best protection throughout its life. It protects even though some small areas of the base metal are exposed. Because of corrosion products it is often unsightly during its life. It cannot be used as a decorative finish, or where the products of its corrosion will affect the function of the apparatus. Zinc or cadmium plates on steel are prime examples.

All other types of plating protect only to the extent that they provide a completely non-porous seal. None of the metal or surface to be protected can be exposed. Usually this type aggravates the probabilities of corrosion at any point or area where the base metal is exposed.

Most plating is of this type, because in addition to the normal or superior protection obtained, beauty and salability are improved as well as wear resistance, mar resistance and overall durability. By far the most popular plates of this kind are nickel and chromium. Gold, silver, tin, and to a much lesser extent palladium, indium, rhodium, and other metals can and have been plated for particular applications. These are usually deposited over copper plates in good commercial practice, though many articles do not require copper preplate.

Binary plates for brass and "white" plating are available. At least one ternary plate of copper tin and zinc is in commercial use. They require more than ordinary control and are economical only on specific applications.

Quality plated ware for improved corrosion or mar and wear resistance, or for enhanced beauty and desirability can be provided to meet almost any sales and service requirement, provided the cost is warranted for the particular part.

Case Histories In Patent Law

H. A. TOULMIN, JR.

[EDITOR'S NOTE: These explanations of the law in specific patent cases are not intended to supplant the services of a patent attorney, whose accurate advice is necessary to handle individual patent problems. The purpose of these explanations is to give a better general understanding of patent law.]

NO. 8

QUESTION: Can a claim in a patent for a new combination of specified means, referring to older mechanism to show the application of that means and the operation of the improvement, be construed as embracing the old mechanism as well as the new?

ANSWER: Many patents taken out in the United States have followed the practice of specifying certain new mechanisms and then of explaining their application to older mechanisms on which the new invention was an improvement to show its application and to show the operation of the improvement in contrast with the older mechanism in prior patents. In some instances the claims are so written as to include the old mechanism and merely add an element of the new mechanism or improvement in order to develop the additional advantage from the mere addition. The courts have held that a mere addition of an element without modifying the old combination is not invention and therefore the claims are invalid.

But in the case where the claim in the new patent for the new combination of a specified means merely refers to older mechanism to show its application in operation of the improvement, it will not be construed as embracing the old mechanism as well as the new. The question always is in each case whether the claim is so drafted as to embrace the old as well as the new in which event it would be invalid or whether the claim is merely referring by way of descriptive orientation to the old application to show the application in operation of the improvement against the historic background of the prior art.

The Supreme Court had occasion to pass upon this matter in recent years in Williams Mfg. Co. v. United Shoe Machinery Corp. 316 U. S. 364. In that case, which dealt with the heel seat lasting mechanism of great complexity, the court construed the claims on the basis that these claims did not merely cover an addition of an old element of the art to an old combination shown by prior patents but the claims rested for their validity upon the fact that they specified a new combination of means producing a new and improved result: and the advantage of them could be better understood by referring to older mechanism in order to show the application of the new mechanism and how the improvement operated as contrasted with the old machines for heel seat lasting.

If, however, a new patent is so drafted as to be merely an extension of an older patent in order to extend the monopoly of the older patent by adding a minor improvement to the older combination of the older patent, then the new patent will be invalid. Bassic Mfg. Co. v. Hollingshead, 298 U. S. 415 and Lincoln Engineering Co. v. Stewart-Warner Corp. 303 U. S. 545.

TECHNICAL NEWS HIGHLIGHTS

Gas Turbines Becoming Lighter, More Efficient

FOR STATIONARY as well as motive power sources, gas turbines are being increasingly refined to smaller, lighter and more efficient units. Significant developments in this field include: (1) A new power unit developed by Brown Boveri, Swiss powerplant manufacturers. Called "Comprex," this radical unit is said to add as much as 50 percent to gas turbine output, and is being installed in a new 4000-hp. locomotive; (2) a new, lightweight gas turbine designed by Westinghouse; (3) a hitherto "secret" aircraft gas turbine being adapted to railroad use.

Turbodyne

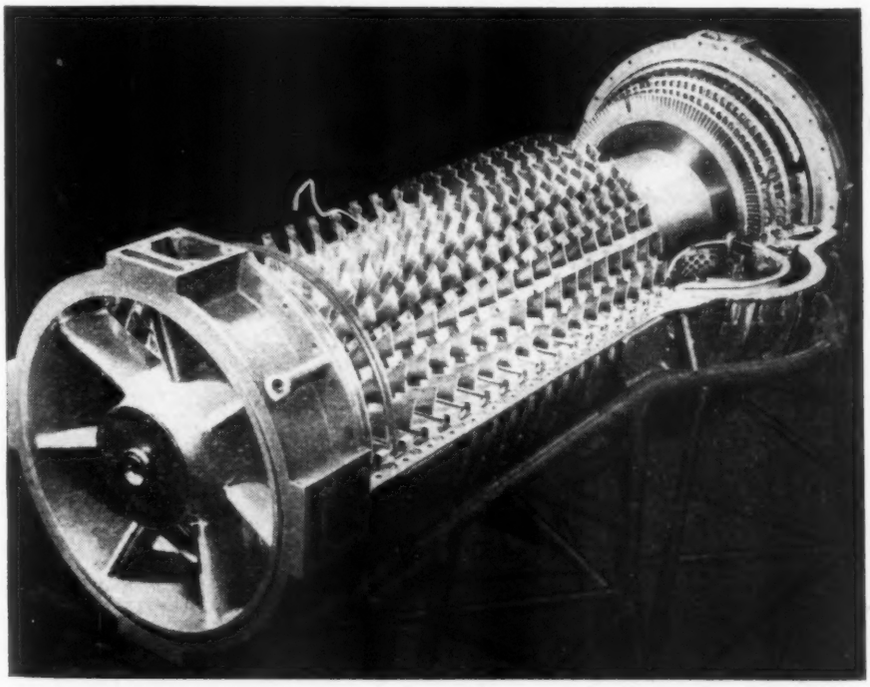
Entering the gas turbine-locomotive race, Union Pacific Railroad has joined up with the Northrop-Hendy Company in a research effort to adapt the Turbodyne—a Northrop aviation gas turbine under development for seven years—to locomotive propulsion. Union Pacific is hopeful that the commercial version of the engine will produce up to 10,000 hp. in replacing diesels of 6,000 hp. This is the first indication that the aircraft version may be the most powerful aircraft engine to be developed so far. The largest pure-jet units yet disclosed develop less than 5,000 hp., but a British Rolls-Royce 8,000 hp. engine has been rumored for some time.

Union Pacific and Northrop-Hendy have many engineering problems to solve before their proposed locomotive gets on the rails. The Turbodyne is a high-powered precision aircraft engine. It operates at high angular velocities and at high combustion temperatures.

Discussions between John K. Northrop and William M. Jeffers, vice-chairman of Union Pacific, led to a working agreement whereby Northrop Aviation "borrowed" a 6,000-hp. diesel-electric locomotive to use in the research program. Although the aviation project was initiated by Northrop, its facilities were taxed by airplane production. An alliance was made with Joshua Hendy Iron Works, and the Northrop-Hendy Company was formed to carry out the turbine development.

The aircraft version has a nozzle temperature of 1,400 deg. F. Estimated life, before re-blading is necessary, is 500 hours. This is impractical for commercial locomotive service. It is proposed to reduce nozzle temperature to 1,250 deg. F., and to cut down rotating speed, and thus obtain a useful blade life of 10,000 hr. This is equivalent to several years' railroad service.

Fuel consumption goes up as nozzle temperature decreases. But extra fuel costs could be offset by savings in maintenance inherent in the gas turbine.

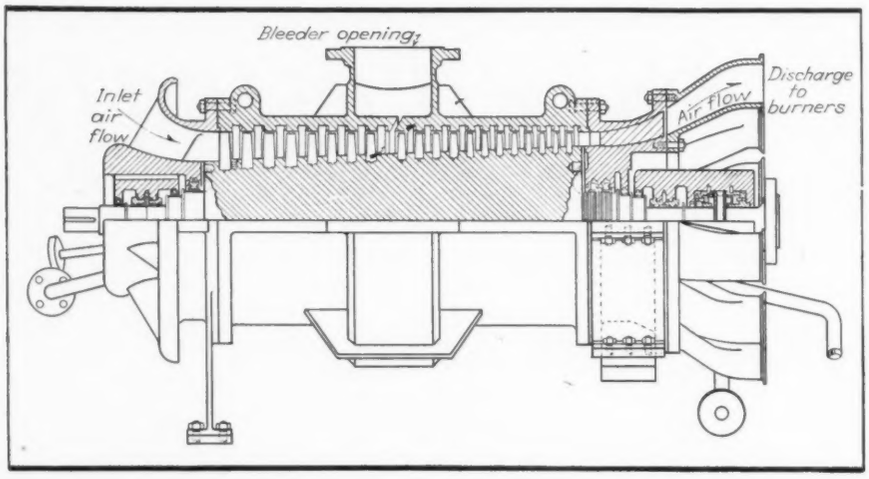


Northrop-Hendy's Turbodyne packs great power into a comparatively small cylinder. Air enters at front, passes through the axial-flow compressor (blades, center), and mixes with fuel in the combustion chamber. The hot gas then strikes the turbine blades (rear). The turbine will drive a "prop-jet" aircraft.

2000 hp. Gas Turbine

AN EXPERIMENTAL 2000-horsepower gas-turbine generator set that weighs only 19 pounds per horsepower and starts in 1½ minutes or less has been developed by the Westinghouse Electric Corporation for industrial, central station, marine, and locomotive applications. Occuping but ¼ cubic foot per horsepower, its light weight, compactness, and quick starting and loading response make possible among other things a gas-turbine-electric locomotive less than half the length and two-thirds the weight of its equivalent in a diesel-electric.

Burning fuel oil to compensate economically for an expected thermal efficiency of its simple open cycle of twenty percent at full load, the gas turbine generator set operates at a top



Cross sectional drawing of the twenty stage compressor used in the Westinghouse gas turbine. The compressor is positioned with respect to the bedplate at the discharge end. The rotor is positioned by a segmental thrust bearing located at the discharge end. The diffuser on the discharge end of the compressor converts a part of the leaving velocity to pressure.

temperature of 1350 deg. F.—the maximum practical temperature using curcently available materials without resort to cooling. The simplest type of open cycle, consisting of only a compressor, combustor and turbine is employed in order that operating experience on these major components may be most quickly acquired, and the useful output is absorbed by a double-armature d-c traction-type generator connected to the turbine through a single reduction gear. Tests to date indicate smooth mechanical performance.

The possible applications of such a simple open cycle gas turbine are numerous. As a locomotive prime mover it can be built in large power within a single cab and would require no cooling water. Four of the present units could be installed in a standard cab.

For marine auxiliary applications it may find a place as a standby power unit and as power booster, and with regenerators and inter-coolers added to raise thermal efficiency it may serve as the main drive. For large ships, however, the closed cycle may be adopted to reduce weight and space.

In the central station field the simple open cycle gas turbine lends itself particularly on the ends of transmission lines to use as a standby unit for peak service. The expense of banked boilers and spinning reserves required of central station steam plants could be reduced by the substitution of low cost, quick starting gas turbines which could be strategically located to cover system peak loads.

Other applications such as portable power plants in the gas fields, power units for gas transmission lines, and power plants for factories where circumstances make it advantageous are all attractive possibilities.

In operation air is taken in by the compressor through the inlet metering nozzle and silencer and compressed to pressures of 30 to 75 lb. per sq. in. absolute, depending on the load carried. Fuel oil is mixed with the compressed air and burned in the combustors, the amount of fuel burned being controlled to limit the temperature of the gases to between 700 and 1350 deg. F. at the combustion chamber outlets. The hot gases are expanded through the power-producing turbine and the resultant exhaust gases pass through a diffuser, elbow, and silencer to the atmosphere.

The turbine develops approximately 6000 horsepower, of which 4000 horsepower is used to drive the compressor. The remaining 2000 horsepower is the useful output delivered to the dc generator.

Standards for Spark Plugs Urged by S.A.E. Committee

MANUFACTURE OF MOTOR VEHICLES throughout the world will be simplified and expedited by the proposed international standardization of spark plugs, according to a report by the electrical equipment committee of the Society of Automotive Engineers. Another benefit derived from this procedure will be increased economy in car operation, according to R. M. Critchfield of the Delco-Remy division, General Motors Corp., chairman of the fact-finding body.

Although spark plugs were partly standardized several decades ago, Mr. Critchfield pointed out, this was abandoned with the advances in automotive engineering. The advent of aircraft power plants and of various cylinder-head materials caused the revision of requirements with an accompanying variety of plug types.

The report shows that there was acceptance of the expedient of "tailor-made" plugs with corresponding holes, but the results were characterized as "definitely chaotic from the standpoint of interchangeability and generally annoying."

The present objective is to establish recommended tapping hole dimensions, to prescribe basic dimensions and tolerance for major, minor and pitch diameters of spark plug screw threads and to set up basic ring and plug gauge dimensions. Engineers say that if these data become the universal rule, manufacturing, maintenance and supply operations will be expedited and simplified.

Wartime necessity is credited with the procedure which is designed to reduce the wide variation of spark plugs to size classifications, thereby simplifying the production job of manufacturers and the maintenance task of operators. Furthermore, it is asserted, manufacturers will be relieved of substantial tooling cost and operators the need for stocking up with numerous slightly different plugs.

The international scope of the project has been undertaken by the electrical equipment committee in conjunction with the aeronautical screw threads committee whose chairman is Gustaf Carvelli of the Wright Aeronautical Corporation.

Coordinated operations of these committees are intended to facilitate progress in automobile and aeronautical manufacture and to permit cooperation with the British in making standards international.

Describing future operations, the joint committee findings pointed out that "world-wide standardization now is regarded as directly helpful to transoceanic transportation and, indirectly, to development of a world market for automotive products."

WASHINGTON NOTES

Federal Science Legislation To Be Reintroduced

Indications in Washington are that this Congress will set up a Federal Science Foundation to subsidize non-federal research. This subject is on the program of "must" legislation for Republican congressmen. Hearings have started, and the strongest measure introduced thus far is a bill by Senator Smith of New Jersey. The Smith measure has the opposite viewpoint on nearly all controversial features from the Kilgore-Magnuson Bill of last year, which passed the Senate but was killed in the House.

Features of Smith Bill—Under the Smith Bill, the Federal Science Foundation would consist of 48 scientists and other professional men, serving part time, who would elect a director and an executive committee to administer the program of research contracts, grants-in-aid, and fellowships. On the highly controversial point of patents, the Smith Bill would require only that equitable patent provisions be included in all research contracts.

Shades of Kilgore—An alternative bill incorporating the features of the Kilgore measure—a full time Presidentially-appointed administrator and public "dedication" of patents on research done with government funds—has been introduced by Senator Thomas, Utah Democrat. Washington feeling is that this measure has little chance for success.

Backers of the Kilgore approach, both among scientists and in government circles, are prepared to accept the Smith Bill rather than no science legislation at all. Indications are that they will attempt a battle in the Senate; they have hopes of winning a small concession in getting responsibility for direction of the foundation vested in a government administrator. There seems to be much less chance that they will succeed in inserting a tight patent clause, although there is an effort to make public a "pigeonholed" Justice Department report which is claimed to go even further than the Kilgore Bill. This report recommends vesting of patents resulting from government-financed discoveries in a federal agency that could license them "selectively."

Industrial Preparedness In Truman's Message

Beneath the surface of the Army-Navy merger legislation which President Truman sent to Congress in March was a proposal for civilian agency to prepare for wartime mobilization of industry—a peacetime "war production board."

In the past, industrial mobilization planning has been the task of the military, even in peacetime. With the advent of war, civilians are called in to manage the industrial phase of war and advance plans are usually set aside. At present, industrial mobilization is the responsibility of the Joint Army-Navy Munitions Board, composed of representatives of the two services, under a civilian chairman.

The President's Plan—President Truman's new plan would set up a civilian National Security Resources Board reporting directly to the President. This civilian agency would take over the job of coordinating military, industrial and civilian mobilization,

Navy Unveils Transsonic Aircraft

DESIGNED TO SURPASS SPEED LIMITATIONS in the transsonic range, the D-558 "Skystreak" was unveiled recently by the Navy's Bureau of Aeronautics, the National Advisory Committee for Aeronautics and engineers of the Douglas Aircraft plant at El Segundo, California. The Skystreak is propelled by the General Electric TG-180 turbojet, which equals the maximum horsepower delivered by the four motors of the B-29. The jet engine occupies the major portion of the fuselage.

Though carrying beside the pilot 500 pounds of recording instruments but no military equipment and advanced in appearance, the Douglas Skystreak's performance characteristics are those of a normal airplane.

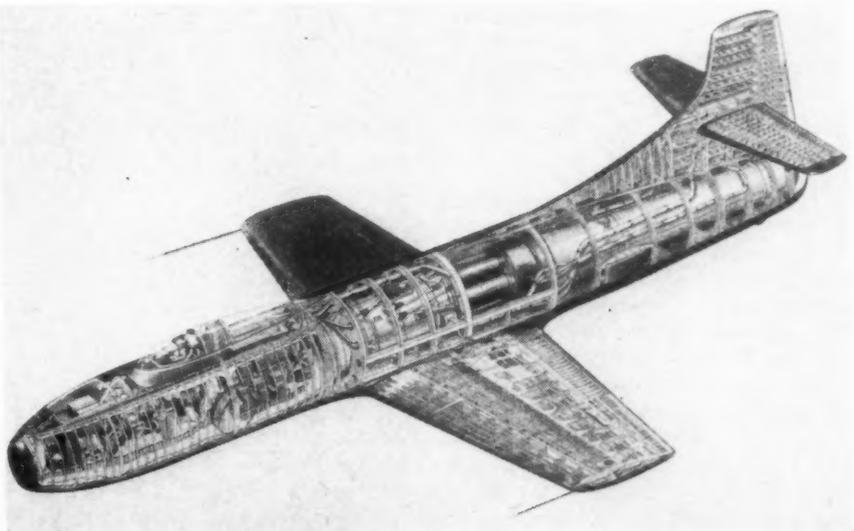
The Skystreak has short, thin wings, a projectile-like body and extremely high elevators and tail. The flush-riveted, polished metal skin is painted brilliant scarlet, lacquered, and polished to mirror smoothness.

The Skystreak is at least 60 percent stronger in construction than current combat airplanes, to withstand the excessive turbulence of air at the velocity of sound. The fuselage has no internal cross-bracing but is one long, smooth tube of extra-thick and tremendously strong magnesium alloy. This metal not only saves weight but allows the fuselage to be wrapped round the engine with minimum waste of space.

Convention aluminum alloy is used in the cockpit and the air ducts. The wings are of 75ST. Counter-weights of tungsten alloy are used for the ailerons to avoid undesirable bulkiness inside the thin wing.

The entire forward section of the Skystreak is jettisonable. In emergency, the pilot breaks the compartment clear, and when it slows down in its fall, he bails out. The impact of air or sudden deceleration might otherwise prove fatal should he bail out in the conventional manner at transsonic speeds. Other safety devices include a pressurized "G-suit," special pads, and harnesses. The cockpit is pressurized, but oxygen is also provided for emergencies.

Integral wing fuel tanks, of 230 gallons, are supplemented by 50-gallon wing-tip tanks to increase range and altitude. The wing tip tanks can be jettisoned at need by a powder charge that forcibly ejects them.



while the Munitions Board would be restricted to planning for the "military phases" of industrial mobilization. In wartime, presumably, the National Security Resources Board would be geared to expand into the roles filled during the last war by WPB, OPA, and the War Manpower Commission.

The immediate responsibilities of the National Security Resources Board would include policy-setting on the program for stockpiling of critical materials—a job now handled by the Munitions Board. NSRB would also be charged with advising the President on "strategic relocation of industries, services, government, and economic activities whose continuous operation is essential to the nation's security." The tremendous task of decentralizing industry into a system of distribution less vulnerable to atomic war is one which the Munitions Board has on its agenda to start thinking about three or four years from now.

Military vs. Civilian—Veterans of the Military-vs.-Civilian "battle" during the last war were startled to find a proposal like NSRB in the merger legislation. That controversy was essentially a dispute between two conceptions on how to organize a war economy. The military view was that soldiers should take what they needed and let the civilian economy get along on what was left. The WPB view held that the whole economy had to be planned and run as a single fighting unit.

Unless Congressional spokesmen for the military change the bill or unless board appointments are weak, Truman's proposal represents a victory for the WPB type of thinking. Last fall, alumni of the WPB, who served under Donald Nelson were urging creation of some such organization on the President. Under President Truman's proposal the NSRB chairman would be presidentially-appointed, reporting directly to the White House. Other members would be "heads or representatives" of the executive departments and independent agencies.

PREROTATING WHEELS on the Lockheed Constitution, 92-ton-Navy transport which made its initial flight in November, saved more than a ton of weight. Dick Pulver, project engineer, pulls out one of rotovane fins on sidewalls of tires, which accomplish prerotation aided by 2 hp. electric motors. Constitution's landing gear is first use of both tandem dual wheels and rotovane tires, on a production basis. Tires foreight main wheels are 50 in. across, for two nose wheels, 44 in. Fins on tires are pulled open at bottom of each revolution of wheel by force of airstream; they close nearly flush at top.

Simplified Practice Recommendations

PRINTED COPIES of Simplified Practice Recommendation R89-46, Coated Abrasive Products, are now available, according to an announcement of the Division of Simplified Practice of the National Bureau of Standards.

This recommendation, a revision of R89-40, includes simplified lists for flint and emery coated abrasives and for coated abrasives other than flint and emery. These lists include type of backing, size of sheet, type of coating, and grade number for each class of goods. The various kinds of products are indicated as standard and non-standard. The standard items are those regularly made by some or all manufacturers and carried in stock by them, and the non-standard items are those which are in limited demand for specific purposes and which may be discontinued when the demand for them changes. The revision which became effective on May 15, 1946, covers certain additions, eliminations and changes in standard and non-standard items to meet current needs.

Copies of Simplified Practice Recommendation R89-46, Coated Abrasive Products, may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 10 cents each.

* * *

Printed copies of Simplified Practice Recommendation R220-46, Open-End and Box Wrenches are now available, according to an announcement of the Division of Simplified Practice of the National Bureau of Standards.

The recommendation covers all double-head, open-end and box wrenches of alloy and carbon steel, except those having openings that are not based on standard bolt sizes, such as small ignition or electrical wrenches, midget-type box wrenches, tappet wrenches, brake wrenches, etc. This simplification program, comprising a list of types and sizes of open-end and box wrenches for regular stock purposes, was developed by a simplified practice committee of manufacturers in cooperation with the Division of Simplified Practice.

Copies of Simplified Practice Recommendation R220-46, Open-End and Box Wrenches, may be purchased from the Superintendent of Documents, 5 cents each.

* * *

The standing committee in charge of reviewing and revising Simplified Practice Recommendation R184-42, Iron Body Valves, has approved a revision of the recommendation, and the Division of Simplified Practice of the National Bureau of Standards has mailed copies to all interests for approval or comment or both.

The original recommendation became effective January 1, 1942, and subsequently served as the basis for mandatory orders issued by the War Production Board. Following revocation of the final of these orders, the standing committee, in cooperation with the Division of Simplified Practice drafted a revision, the purpose of which is to retain the essential purpose of the original recommendation and include those features of the war-time order which the industry found to be of benefit to producers, distributors and users.

The proposed revision applies to the usual types of iron gate, globe, angle and check valves for primary pressures of 25-, 125-, 150- and 250-pounds, and 100- and 800-pound pressures for water, oil and gas. A simplified range of sizes is given for the various types and kinds of valves for each of the pressure ratings.

General adoption of the revision as a standard of practice should result in economies to all concerned in the production, distribution and use of these valves.

Should the revision as proposed, or as adjusted in accordance with suggestions submitted during the review period, meet with general approval, it will be promulgated and printed. The effective date will be announced later.

Mimeographed copies of the proposed revision may be obtained from the Division of Simplified Practice, National Bureau of Standards, Washington 25, D. C.

RESEARCH NOTES

Cycle-Testing Laboratory For Aircraft Batteries

A new laboratory for battery research has been constructed at the National Bureau of Standards with the cooperation of the Bureau of Aeronautics, Navy Department. Equipped with completely automatic controls for cycling batteries, this laboratory offers a unique method of testing batteries under conditions simulating those encountered in practice—conditions that are particularly important for aircraft batteries. Such problems as maximum electrical capacity per unit weight, charging techniques, and the effect of these techniques on battery life, will be investigated.

In present day aircraft, the storage battery plays an important role in the operation of electrical equipment such as radio, radar, and lighting. It also serves as a source of standby power in the operation of the gun turrets, bomb bays, and retractable landing gear. Since every pound added to a plane increases the takeoff distance, weight is also of major concern. Hence, obtaining maximum capacity per unit weight of the battery with reasonable life expectancy is the principal aim of the experimental tests conducted at the Bureau of Standards.

The equipment in the laboratory provides for discharging the batteries through constant resistance and recharging them either at constant potential or at constant current, as desired. The cycling may be performed automatically for batteries at room temperature, extreme heat, sub-zero temperatures, and "flight" vibration.

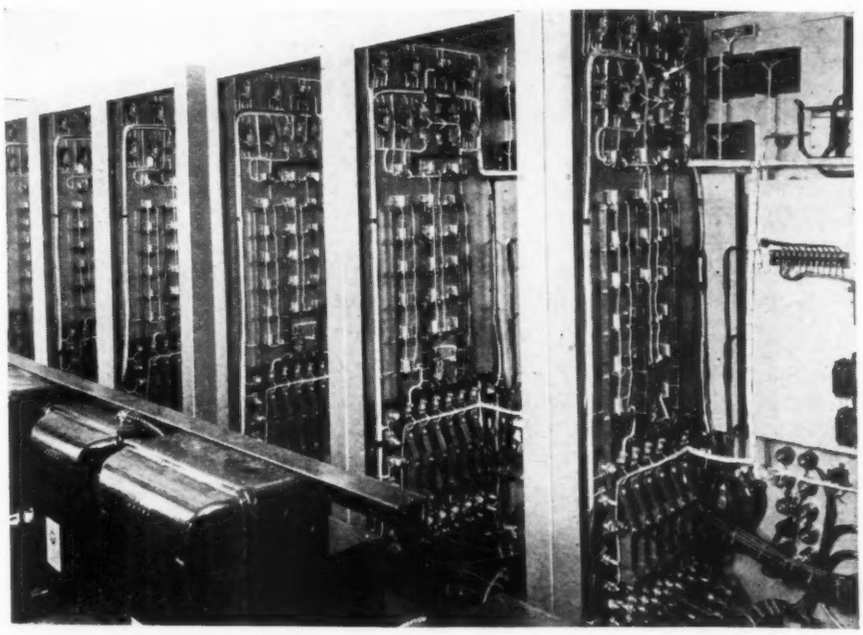
Six similar cycling units have been installed, each operated independently by a master electric clock. Each unit consists essentially of a control cabinet, two motor-generator sets, and the necessary resistors. From one to six 24-volt batteries may be cycles on each unit, the only requirement being that the batteries on a given unit have approximately equal rated capacities. When charging at constant potential, the batteries are connected in parallel; when charging at constant current or when discharging, they are connected in series. Connections are made automatically.

Alternating current, received at 2300 volts, is stepped down to 230 volts for operating the motor-generators and auxiliary equipment. The power transformers and main resistor units are located outside the laboratory.

An important feature of the laboratory is the control cabinet. One is provided for each cycling unit and contains a program machine for automatic cycling, sequence relays, contactors (aircraft type), and a copper oxide rectifier which supplies 24 volt current for operating the switching devices. Three single phase transformers located in alternate control cabinets supply 115 volt alternating current for the rectifiers. The transformers are supplied by the respective phases of the alternating current for the motor-generator sets.

Extensive experimental tests are now under way in the cycle-testing laboratory. It is believed that final and conclusive data from these tests will give an accurate comparison between the two methods—the constant potential and constant current—of charging and their effect on the life of batteries.

The general plan of the laboratory was developed by C. L. Snyder, National Bureau of Standards, with the cooperation of Lt. Kenneth Dawkins of the Bureau of Aeronautics. Engineers of the Standard Electric Time Company worked out the details for the automatic controls and constructed the control cabinets. The resistor units were designed and constructed by members of the National Bureau of Standards, who also designed the layout and installed the equipment.



Control cabinets tor the six cycling units in the new cycle-testing laboratory at the National Bureau of Standards. Inside of each cabinet are the sequence relays mounted in two horizontal rows near the top, the contactors in the middle, and the shunts in two horizontal rows near the bottom.

Proper Sampling Methods Improve Quality Control

MEASUREMENT AND SAMPLING METHODS to insure that only acceptable parts and components are being made during the manufacturing process rather than dependence on inspection methods to eliminate defective articles after they have been manufactured are described in a report for sale by the Office of Technical Services, Department of Commerce. The report states that at Picatinny Arsenal, Dover, N. J., such "quality control" by statistical methods reduced the cost of inspecting tetryl pellets for bomb fuzes by 48 percent and saved $25,000 a month in the inspection of detonator charges.

The report, prepared by Frank P. Harris of the Arsenal's production engineering section, contains a history of quality control as applied at Picatinny and an appendix with detailed instructions for sampling inspection prepared by Captain A. C. Cohen.

Scientific methods of sampling are particularly important in the case of ammunition because exploding tests are destructive, and if every piece is tested nothing is left. Enough samples must be tested to show how the product performs but excessive testing is wasteful, the report points out. Accordingly, tables were scientifically worked out to show the number of samples required to keep amount of testing as small as possible and still guarantee the acceptability of the entire batch within a calculated "consumer's risk"

as to the probable chances that any piece would be defective. The tables, given in the report, show the number of samples that must be inspected depending upon the size of each batch or "lot" and the number of defectives discovered.

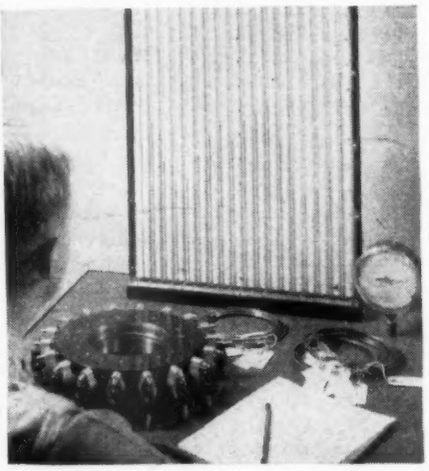
The use of quality control by statistical methods at Picatinny Arsenal by Col. Leslie E. Simon and Dr. W. A. Shewhart of the Bell Telephone Laboratories has had a marked influence in acquainting American industry with this scienific method of attaining good quality in manufacture, the report states.

Besides savings of material when the tests are destructive, there is a saving of manpower, according to the report. Scientific sampling reduces the number of articles that must be inspected and thus reduces the number of inspectors required. In many cases, complete inspection of scientifically determined representative samples may be more accurate than so-called "100 percent inspection" which may be faulty because of fatigue or inattention of the inspectors.

Quality control involves observation of the manufacturing processes and correction of any operation before defectives are made as well as scientific determination of the number of samples to select for test. Information on the various operations, prepared in the form of charts, is a most important aid in saving manufacturing costs, the report states. Measurements made at regular intervals show any trend away from the specified dimensions and machines can thus be adjusted before they exceed tolerance limits and produce defective articles.

Control during manufacture is particularly effective when parts and subassemblies are later assembled to make the complete article. Accurate control of dimensions and properties of individual parts insures proper fitting and operation and reduces the chance of producing either "duds" or "lemons". Moreover, when parts are made under strict quality control there is much more assurance that they will be interchangeable. The methods used in applying quality controls techniques are described in the report and sample charts and photographs of inspection processes are also given.

The report, Quality Control at Picatinny Arsenal (PB-39492; Photostat, $18; microfilm, $6; 263 pages, including forms, graphs, and photographs; March 1946) and separate copies of Captain Cohen's detailed instructions, Quality Control Through Sampling Inspection (PB-39493; photostat, $4; microfilm, $1; 46 pages, including charts, tables, and curves; October 1942) are available from OTS.



NEW ACCURACY IN PISTON RING TESTING—Giving speedier, highly accurate piston ring measurements this new piston ring guage was developed by Gulf Research and Development Co. in cooperation with the aviation industry. In effect it consists of 18 Solex gauges, measuring the pressure at all points on the piston ring circumference. The pressure is recorded on mercury columns. Only 15 seconds are required for testing of a ring and the device may be set up to take rings from 6⅛ to 2½ in. The new piston ring gauge is now being used also in the auto industry.

Dip Soldering of Aluminum

Aluminum tubular radiators which resist corrosion in soldered areas can be made by dip soldering according to a German Air Research Ministry wartime report now on sale by the Office of Technical Services, Department of Commerce.

Dip soldering avoids soft solder and has sufficient strength and adequate chemical stability if certain conditions are maintained, such as pretreatment of the aluminum and use of proper solder and flux, the report states. The German investigators claimed that corrosion of aluminum caused by water in the soldered areas of radiators was prevented by use of a eutectic mixture of zinc and cadmium with an intermediate layer of iron. The report includes 30 photographs of tubular radiators and radiator sections as well as photomicrographs enlarged up to 300 diameters.

Orders for the report (PB-36637; Dip Soldering of Aluminum; microfilm, $1; photastat, $2; 29 pages) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the United States.

Research Fellowship On Reinforced Concrete

The prime objectives of the research program on reinforced concrete now under way at the National Bureau of Standards by a fellowship of the American Iron and Steel Institute are improved design of concrete reinforcing bars and engineering data that will enable engineers and builders to make more effective use of reinforced concrete. A mechanical bond—that is, a bond which will resist slipping of the bar within the concrete—is set up between the reinforcement and concrete, and the effectiveness of the reinforcement is dependent on this bond. The investigations by the fellowship constitute fundamental research into the mechanism of this bond and factors that affect bond strength between the concrete and reinforcing bars.

Reinforcing bars, with ribs or ridges of various patterns, are known as deformed bars, and as many as twenty designs of these bars are commercially available. Although it is generally recognized in the industry that some of these are more effective in developing bond than others, minimum requirements for deformed bars have not been established. One purpose of this investigation is to set up criteria that will define a satisfactory deformed concrete reinforcing bar and eliminate the less effective of these designs. On the basis of preliminary data, the members of the American Iron and Steel Institute who are producers of reinforcing bars have discarded from further consideration all but five designs.

The test procedure for determining relative bond efficiency, prepared through the cooperation of a committee of the American Concrete Institute, of which H. J. Gilkey is chairman, has been published as a proposed standard of the American Concrete Institute. Taking into account the many factors that affect the character of the bond, specifications cover the composition and quality of the concrete, the location and length of embedment of the bars in the concrete, construction of the molds and assemblies, details of casting and curing, and methods of testing the finished specimen.

Microwave Unit Penetrates Solid Objects

SCIENTISTS in the General Electric Company's Research Laboratory can "see" through walls and around corners with the aid of a newly-developed device called a "microwave unit." Combining characteristics of both the electric eye and radar, this unit is expected to have many practical applications.

In contract to the electric eye, the microwave unit sees by means of high-frequency radio waves, rather than a light beam. By means of a parabolic reflector, these microwaves are focused in a beam and reflected from objects, similar to the way that radar impulses and a beam of light are reflected.

Unlike light, beams are reflected from dark or rough surfaces. Besides being reflected, the beams may be made to pass through such objects as a brick wall, and can be directed in a circuitous path by means of a hollow metallic pipe.

Resembling a large flashlight, the device weighs only four pounds, and the whole unit, comprising tube, circuit, transformer, antenna, and reflector, is small enough to be held in one hand. It is operated on ordinary house alternating current, which it converts into electromagnetic waves of about five inches in length.

The wartime development of the General Electric "lighthouse" tube, in combination with a suitable oscillating circuit, has made possible the building of this simple source for a microwave beam. For receiving the radiated beam, a similar dipole antenna, placed at the focal point of a parabolic reflector, is employed. A silicon crystal detects the microwave beam, and the resulting output can be made to indicate on a meter the radio field intensity, or to operate a relay which in turn activates a bell or other device.

Like the photoelectric eye, the microwave unit can be used to perform such tasks as counting, diverting, opening, closing, discarding, signaling, limiting, and protecting. And it claims the added feature of doing these things through a non-metallic barrier such as a wall, partition, or housing.

Electrolytic Metal Polishing Developed at Frankford

TWO NEW TECHNIQUES for electrolytic metal polishing, which were developed at Frankford Arsenal, Philadelphia, during the war are described in a report by the Office of Technical Services, Department of Commerce. The new methods are claimed to give more rapid results to require less skill than mechanical polishing and to prevent "flowed" or "worked" layers in polished surfaces. The report was written by Joseph Mazia, associate metallurgist of the Ordnance Laboratory, Frankford Arsenal.

One of the new techniques involves the use of a portable brush electrode for polishing individual areas of heavy and cumbersome objects which do not lend themselves to mechanical treatment or to electrolytic polishing in a tank. The brush electrode is made of a metallic core enveloped in a solution-retentive dielectric material. The core of the brush is made cathode, and the brush itself is moistened with a suitable electrolyte. A direct current source up to 12 volts is used for the polishing, which is done anodically by pressing the brush gently against the object to be polished.

The principle of brush polishing was

Army Ordnance Mammoth Truck-Dynamometer

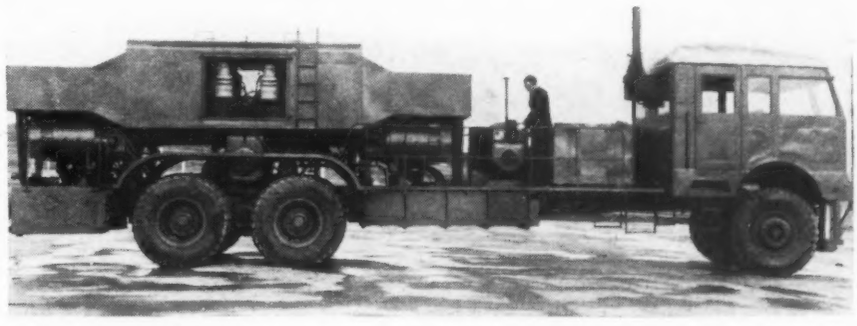
A MAMMOTH 60-TON, 1,000 hp., 45 m.p.h. combination truck-dynamometer, built through the cooperative efforts of the General Electric Company, the Knuckey Truck Company of San Francisco, and the U. S. Army Ordinance Department, has appeared on the Aberdeen Proving Ground, Md. Primary purpose of the 40 foot, gasoline-electric giant dynamometer is to test the tractive effort of large Army wheeled and tracked combat vehicles over various types of terrain. As such, it rates a maximum drawbar pull of 60,000 pounds at speeds as low as two

Employed as a prime mover to tow test equipment, such as heavy field pieces and trailers, to ascertain tractive rolling resistance, the truck rates continuously 38,000 pounds tractive effort at a speed of 2.5 m.p.h. As a truck functioning merely to propel itself, the vehicle is capable of 60,000 pound tractive effort and a top speed of 45 miles per hour. The 1000 hp. drive is provided by two 500 hp., engine-generator power plants, each consisting of a Ford tank engine and a General Electric traction generator. Each generator supplies power to two traction motors which drive the wheels through sprocket and chain drive.

The dynamometer can be operated with one or both power plants. Engine speed is controlled by an electro-hydraulic governing system. Automatic overload and current limit electrical circuits protect the engines and generators from damage. Amplidyne exciters furnish excitation for motors and generators.

The cab of the massive vehicle accommodates a driver and load-control operator. Dynamometer or load-absorbing operation is controlled by both the load-control operator and the driver. The dynamometer or load-control operator controls the electrical load on the towed vehicle. Mounted on a small panel, directly in front of the operator, are a control switch, which makes the electrical load circuits operative, and three control knobs. The load-control operator can increase or decrease dynamometer load absorption by means of the three knobs. Operational performance of the dynamometer is recorded by draw bar strain gage equipment and elaborate speed, time, and fuel consumption instruments.

Aberdeen Proving Ground, Maryland



At the front of the dynamometer is the mounting column for the draw bar attachment. Directly behind the cab are the large fuel tanks which supply fuel for the V-8 engines. The auxiliary engine for the jack shaft lubricant can be seen behind the tanks. The stack attached to the rear of the cab is the roto-clone blower for changing the air in the cab.

to develop a second technique, an "electrolytic lapping" process, for polishing metallographic specimens. This method involves the use of a stationary lapping disc of similar construction to the brush electrode. In this case, however, the object to be polished is made anode and is moved over the disc, which is moistened with the electrolyte.

German Open-Center Hydraulic Systems

Though most German hydraulic engineers would have preferred piston pumps, they used gear pumps almost exclusively during the war. Permission to use piston pumps was not granted until the last year of the war because the German Air Ministry was not convinced that the increased performance of piston pumps as compared with gear pumps was worth the added cost in man-hours.

The Germans believed that a variable volume piston pump developed late in the war by the Askania firm in Berlin would have been particularly desirable in their open-center system. This pump automatically returned its output to or near zero when the selector valves were in neutral. This prevented the circulation of large volumes of fluid and resulting power loss. In the Germans' opinion, this pump would have served the same function as an accumulator in speeding up operation of units, without having any of the disadvantages of the accumulator.

Air Springs On Railroad Trucks

AN EXPERIMENTAL APPLICATION of air springs to railroad passenger car design and greatly increased passenger comfort, has been tested by research engineers of The Firestone Tire and Rubber Company and the Pullman-Standard Car Manufacturing Company.

This innovation was given its first public tryout in a special run over the tracks of the Chicago, South Shore and South Bend Railroad between Michigan City and Chicago. Used in the experiment was Pullman-Standard's special laboratory car, one end of which was equipped with air springs and the other with steel coil springs. Instruments recorded lateral and vertical motion.

Foreign Reports

. . . . . from McGraw-Hill World News

Screw Thread Unification Tested

In connection with the recommendation of the Ottawa Conference on the Unification of Engineering Standards to standardize a common British-American "unified" screw thread, (see April, 1946 "Industry and Societies"), the British Standard Institution Screw Threads Technical Committee is gathering evidence regarding the degree of interchangeability of bolts and nuts made with the Whitworth and proposed "unified" thread forms. In practice the question of interchangeability would arise only in connection with the recommended "unified" coarse pitch series and the British Standard Whitworth (B.S.W.) series, since these series, in common with the American National Coarse thread series (A.N.C.), have the same diameter-pitch relationships in the majority of sizes.

The proposed "unified" thread form approximates closely the American National form of thread, and an investigation has been made at the National Physical Laboratory, on the interchangeability of certain sizes of B.S.W. (medium fit) and A.N.C.2 bolts and nuts.

Calculations show that the possible interference is greater between a maximum metal A.N.C. nut assembled with a maximum B.S.W. bolt of the same nominal size than between a maximum metal B.S.W. nut assembled with a maximum metal A.N.C. bolt of the same nominal size. The more difficult case of assembly, A.N.C. nut on B.S.W. bolt, was, therefore, chosen for the investigation.

Several hundred bolts of each of the three commonly used sizes ¼ in., ⅜ in., and ⅝ in. B.S.W. were used. These bolts and the corresponding sizes of A.N.C.2 nuts are generally representative of current practices.

The screw threads on the bolts and nuts were brushed, and in some cases wiped with a paraffined rag to remove dirt. All the nuts of any one size were thoroughly mixed, and then each B.S.W. bolt was assembled, first with a hexagon A.N.C.2 nut, secondly with a square A.N.C.2 nut and finally with a B.S.W. nut. The criterion of an acceptable assembly was that it should be possible to screw the nut on the bolt, using the fingers only, until the leading thread of the bolt showed clear.

The results for several batches were not homogenous with the remaining results. At least one of these batches of bolts was carefully examined, and the threads found to be tapered and oversize in places. The B.S.W. nuts supplied with these bolts only fitted because they were correspondingly oversize. Excluding these results, the percentages of misfits in the assembly of ¼ in. B.S.W. and A.N.C.2 nuts with B.S.W. bolts, were less than 5 percent and for the ⅜ in. size about 10 percent in both sizes. Thus, for these two sizes there was as great a probability of a misfit occurring with a B.S.W. nut on a B.S.W. bolt as for an A.N.C.2 nut on a B.S.W. bolt.

For the ⅝ in. size, the difference between the results for the two kinds of nuts was more noticeable. The percentage of misfits in the assembly of ⅝ in. A.N.C.2 nuts with B.S.W. bolts was about 50 percent whereas the corresponding value for the B.S.W. nuts was of the order of 20 percent.

Where a nut could not be screwed on with the fingers, there was a strong suspicion that the trouble was caused by small bruises on the thread, and that assembly would be possible by the use of somewhat greater force than could be applied merely with the fingers. For several batches, chiefly on the ⅝ in. size, this was proved by screwing on all the "misfits" by hand, instead of the fingers, and without recourse to a spanner.

Belgian Industrial Show

A total of 3,000 exhibitors have taken space in the International Commercial Fair which will be held in Brussels from April 26 to May 11. Twenty countries exhibiting in 26 industrial groups will participate.

ASA Publishes Standards List

A LIST OF 864 STANDARDS approved for national use of industry by the American Standards Association has been made public and available for general distribution. The revised list of standards, which includes many of those developed under war procedure and now approved for peacetime use, will be made available to interested trade, technical, and governmental bodies and individuals without charge.

The standards listed include definitions of technical terms, specifications for metals and other materials, methods of work and methods of test for finished products. They reach into every important engineering field. They also include standards dealing with public and industrial safety, industrial medicine and consumer goods.

MEETINGS

April 16-18
Society of Automotive Engineers—Transportation Meeting, Hotel Stevens, Chicago, Ill.

April 17-19
National Aircraft Standards Committee—National Meeting, Dayton, Ohio.

April 28-29
American Zinc Institute — Annual Meeting, Hotel Statler, St. Louis, Mo.

April 28-May 1
American Foundryman's Association—51st Annual Convention, Book-Cadillac and Statler Hotels, Detroit.

April 29-May 1
Industrial Packaging and Materials Handling Exposition—Hotel Sherman, Chicago, Ill.

May 1-2
Society of Automotive Engineers—Personal Aircraft Meeting, Hotel Lassen, Wichita, Kansas.

May 5-11
Society of the Plastics Industry—National Plastics Exposition, Coliseum; Annual Meeting, Hotel Stevens; Chicago, Ill.

May 6-8
Petroleum Industry Electrical Association Conference—Rice Hotel, Houston, Tex.

May 15-17
Society for Experimental Stress Analysis—Annual Meeting, Stevens Hotel, Chicago, Ill.

May 21-24
American Society of Mechanical Engineers—Oil and Gas Power National Conference, Cleveland, Ohio.

May 22-31
Mid-America Exposition—Cleveland Public Auditorium, Cleveland, Ohio.

May 26-29
American Society of Mechanical Engineers — Aviation Meeting, Los Angeles, Cal.

May 27
Metal Powder Association—Spring Meeting, Waldorf Astoria Hotel, N. Y.

Torquing of Nuts Report by SAE

BASIC DATA for the assembly of aircraft engines, also of benefit in the assembly of automotive engines, are covered in a recent report "Torquing of Nuts in Aircraft Engines", published by the Special Publications Department of the Society of Automotive Engineers. The recent great increase in the production of aircraft engines, the corresponding increase in the number of manufacturers of this type of internal combustion engine, and the costly service failures encountered pointed to the need for recommendations as a guide in the proper tightening of nuts on bolts and studs. A special Torquing Committee of SAE was established to assist manufacturers and users of this equipment by establishing these procedures and recommendations.

The report investigates the causes of bolt and stud failure and the means for avoiding such failures, which, some experts feel, have not been fully understood. Contrary to normal concepts of strength of materials extensive data obtained from laboratory tests, and confirmed by tests in actual service, show that the strength of most bolts and studs, when used as clamping members, is primarily a function of the tightness of the nut. The effects of design, of material and heat-treatment are compared with the effect of the initial tension in the bolt in relation to operating load. Test data are included showing the variation in nut tightness that results from several kinds of electro-deposited metals and the variation in tightness caused by normal variation in friction.

Data presented in the report were contributed by: Allison Division, General Motors Corp.; Buick Motor Div., G. M. Corp.; Chevrolet Motor Div., G. M. Corp.; Chrysler Corp.; Ford Motor Co.; Lycoming Div., The Aviation Corp.; Packard Motor Car Co.; Pratt & Whitney Aircraft Div., United Aircraft Corp.; Research Laboratories Div., G. M. Corp.; Studebaker Corp.; and Wright Aeronautical Corp. The report can be obtained from Special Publications Dept., Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y., $2 to SAE members; $4 to nonmembers.

Standardization and Research At A.S.T.M. Committee Week

LARGEST REGISTRATION in the society's history marked the A.S.T.M. Committee Week and Spring Meeting held in Philadelphia during the week of February 24. Increased activity of the society was reflected in the dedication of the new headquarters building located on Philadelphia's Parkway at Logan Square. Purchase and enlargement of the building, a four-story structure, was made possible through gifts from A.S.T.M. members totaling $160,000. Improved working facilities are provided for the society's staff and for committee meetings.

Technical highlight of the meeting was the symposium on paint and paint materials. Under the chairmanship of

MACHINE TOOL SHOW LARGEST IN WORLD

WORLD'S LARGEST EXPOSITION of a basic industry, the 1947 Machine Tool Show will be held in the Dodge-Chicago plant, Chicago, Illinois, from September 17 through September 26. Housing more than 250 exhibits of metalworking machines and related equipment, the exposition will occupy 500,000 sq. ft. Held under sponsorship of the National Machine Tool Builders' Association lease for the space has been taken over from the War Assets Administration.

Theme of the show will be greater production and sales, with lower prices. Most recent methods of machining, new kinds of raw materials and latest equipment will be shown. Admission to the show will be by invitation. Advance registration of industrialists, supervisory personnel and engineers will be arranged through the Association's office at 10525 Carnegie Avenue, Cleveland 6, Ohio. The show will be open daily from 10 a.m. to 5 p.m. Technical sessions of the Machine Tool Congress will be held each evening at various Chicago hotels, headquarters for participating groups.

C. H. Rose, National Lead Company, a joint committee with representatives from Committee D-1 on Paint, Varnish, Lacquer, and Related Products, and the Philadelphia Council, sponsored the symposium program, which included discussion by leading authorities. The symposium was arranged in three parts — one concerned with methods of evaluation of paints; a second with the evaluation of paint materials; and a concluding discussion on statistical analysis of paint test data—in all, eleven papers were presented. The A.S.T.M. will publish the symposium in book form later in the year.

DISCUSSIONS AND COMMENTS FROM READERS

Division Status Granted To Machine Design Group

THE FOLLOWING LETTER reports an action taken by the A.S.M.E. that is of great importance to all design engineers. The letter was addressed to the members of the Executive Committee of the Machine Design Group of the A.S.M.E. and reads as follows:

It is with pleasure that I can notify you that today in a letter from James N. Talbot, Chairman of the Professional Divisions Committee of the A.S.M.E., I have been notified that the Machine Design Group has been granted the status of a Division—so from now on, it is legal for you to call us a "Division" instead of a "Group".

I think a great deal of credit is due the past and present Executive Committee, the Advisory Committee and the Papers Committee, to be able to make this advancement so quickly, and I would like to state in this letter that in my opinion, the big part of the honor should go to J. F. Downie Smith, our first Chairman. I know personally, having worked with Downie, that he put in a lot of effort and hard work to bring our Machine Design Group through during the first and most trying year. I was glad to see that a copy of Mr. Talbot's letter was sent to Downie, and I know that it will make him quite proud that Divisional status has been accorded to our Group. At the same time, it makes me feel rather proud of the fact that through his efforts, I have the honor of being made the first Chairman of the Machine Design Division.—B. P. GRAVES, *Chairman Machine Design Division, ASME*

EDITOR'S NOTE: PRODUCT ENGINEERING echoes the sentiments expressed by Ben Graves, Director of Design of the Brown & Sharpe Manufacturing Company in the above letter.

We wish to further report that Dr. J. F. Downie Smith, who has been Director of Engineering and Research of the United Shoe Machinery Corporation, has recently been appointed Dean of Engineering, Director of the Iowa Engineering Experiment Station, and Director of the Engineering Extension Service at Iowa State College.

It is most fitting that the accomplishment of Dr. Smith in stimulating the organization of the Machine Design Group and serving as first Chairman, has received recognition of the effectiveness and efficiency of his work by the granting of Divisional status to this group on the basis of the recognition which it earned in only one year.

It is further fitting that the first Chairman of the Machine Design Division is B. P. Graves, who has shown unflagging interest in the engineering design activities of the A.S.M.E. and in supporting Dr. Smith.

Are Manufacturers of Aircraft Electrical Equipment Ultra-Conservative?

To the Editor:

During the war it was the duty of government engineers to evaluate the merits of equipment designed by manufacturers, and to guide developments. This was generally done in a spirit of cooperation looking to the common objective of the effective prosecution of the war. Such development work is still going on, of course, minus the incentive of wartime urgency. There were many shortcomings in this procedure, with young engineers criticizing the work of men of long years of commercial experience, and the latter perhaps being handicapped by prejudice and habits of thinking. On the whole a fairly good balance was achieved between radicals and conservatives; and there is no particular point in looking backward with the idea of proving that a better job might have been done.

However, there is one criticism of the manufacturers of aircraft equipment which may have been overdone. That castigation is that maximum weight reduction has not been achieved because of a tendency to adhere to commercial ideas of temperatures, speeds, and construction features in general.

It is time someone took the other side of the fence and brought home the fact that it is possible for weight to be reduced at the sacrifice of reliabilty. One wearies of claims such as, "We now have a 5 hp. motor in a 3 inch diameter." Usually specifications are not given as to speed, overload torque, duty cycle, cooling, and life under service conditions.

It is perfectly legitimate and straightforward engineering to use tubing instead of solid steel for shafts——metal at the center of the shaft is not paying its way. Similarly, armature punchings should be so designed that there is no point at which flux density stays below the saturation point. However, it is questionable engineering to use tin-can construction for enclosures so that a flick of the finger can produce a dent, and end cover construction and fits barely adequate to hold the rotor concentric enough on one sample in the laboratory to run 1000 hours and to survive shock and vibration test.

A laboratory test on one sample motor is not the acid test. Quantitative experience with a given class of product is necessary before there is assurance that failures will not exceed a reasonable percentage. And failures at 30,000 feet in the air are frequently more serious than a failure of a kitchen drink mixer.

In general, manufacturers made complete new dies, patterns and fixtures, used special steel sheet, employed magnesium die castings where applicable, used unheard of flux and current densities, and generally disregarded commercial practices except as a foundation of principles and facts. Basic formulas have not changed much. New developments come slowly, such as silicone varnish to make feasible increased use of higher temperature insulating materials while retaining desired factors of safety.

Manufacturers have been regarded as unduly conservative in refraining from going to speeds of the order of 20,000 rpm. Even if brushes can be kept on commutators and parts can be kept in place, one needs only to look at a statistical chart of bearing life and note the effect of speed on mortality to judge there are limits today for any given size and set of conditions beyond which common sense would not lead. Real progress will be made by intelligent evaluation of all of the factors involved, with continuous refinement in details permitting new hoizons in overall accomplishment. —C. T. BUTTON

NEW BOOKS

Plastics Handbook For Product Engineers

JOHN SASSO. *First Edition. 468 pages, 6x9 in., Rust clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. Price* $6.

This is a collection of engineering data on plastics and synthetic rubber that aims to present practical information of specific use to the engineer planning to adopt these new materials to product designs. In concise handbook form, the book is divided into three parts: Plastic Materials, Design of Plastic Products, and Rubberlike Materials. The chapters on chemistry of plastics and synthetic rubber were prepared by Paul O. Powers of the Battelle Memorial Institute. Much of the remaining text has been briefed from material that originally appeared in PRODUCT ENGINEERING. Although not intended as an original source book of plastics data, it supplements such published data in order to help product engineers in the selection, design and processing of plastics.

Welding Aluminum and Aluminum Alloys

Prepared and published by the Reynolds Metals Company, Inc., Louisville 1, Ky. 87 pages, 6x9 in., spiral bound. Price $1.

A discussion of the various methods of welding aluminum and aluminum alloys. Methods of joining by gas, arc, and resistance welding, brazing and soldering are discussed. Proper application of these various methods and their limitations are covered. Some details of design and procedures are given for the various welding methods.

Aircraft Layout and Detail Design

NEWTON H. ANDERSON. *437 pages, 5½x8½ in. Maroon fabricoid covers. Published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. Price* $4.50.

This text covers the three main topics of interest to the aircraft layout draftsman: (1) Descriptive geometry, (2) Detail design, (3) Fitting analysis. Since, in order to get started on his layout, the draftsman must have a working knowledge of certain parts of descriptive geometry, only those portions that have common application to aircraft structures are included. There has been no attempt made to stress especially methods or procedure of manufacture, as the basic idea of this book is to teach aircraft draftmen to create a design that can be made in the shop with a minimum of effort and expense. Sufficient stress analysis is discussed to enable the draftsmen to design parts having the required strength with a minimum of weight.

Quartz Crystals For Electrical Circuits

RAYMOND A. HEISING, *Radio Research Engineer, Bell Telephone Laboratories. 563 pages, 6¼ x 9¼ in., blue clothboard covers. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Price* $6.50.

A coordinated compilation with sixteen chapters written by members of the technical staffs of the Bell Telephone Laboratories and a final chapter prepared by two manufacturing engineers of the Western Electric Company, Inc. Each chapter presents the general technical art and pertinent textbook science summarized by an engineer who has specialized in that particular phase.

The book includes chapters on quartz crystal applications, specifying orientation, raw quartz, principles of mounting, shaping, depositing metal electrodes, effect of manufacturing deviations, and measurement of performance index.

Inductance Calculations

FREDERICK W. GROVER, *Professor of Electrical Engineering, Union College. 286 pages, 6¼ x 9¼ in., tan clothboard covers. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Price* $5.75.

Of especial interest to electrical and communication engineers, this book provides many types of inductors with a single simple formula that involves only the parameters that naturally enter together with numerical factors that can be interpolated from tables computed for the purpose.

All important cases are included, and in the more complex arrangements of conductors a straight forward procedure is outlined. Certain of the tables are useful in more than a single case, but even so the tables represent a vast amount of computation. The tabular intervals are chosen so that where possible linear interpolation or at worst the inclusion of second order differences suffice. Illustrative examples are included with each case and where possible the numerical values found have been checked by other known formulas or methods. Procedure for the design of the more usual types of inductor is included.

The 24 chapter topics include discussion of methods of calculating inductances, circuits composed of combinations of straight wires, mutual inductance of coaxial circular coils, special types of single coils, calculation of magnetic force between coils, and high frequency formulas.

Trigonometry Refresher for Technical Men

A. ALBERT KLAF. *629 pages, 5½ x 8½ in. blue-gray clothboard covers. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. Price* $5.00.

In this book the term refresher is used because of the manner of treatment and not because of the omission of pertinent material. Its aim is to present the subject of plane and spherical trigonometry to technical men who desire rapid comprehension. Features of this book include a simplification of the principal functions of an angle by the use of a "shadow and perpendicular" concept, a progressive development of logarithms and an intensive chapter on the theory, construction and use of the straight slide rule.

Mathematics for Engineers

RAYMOND W. DULL. *346 pages, 5¼x8¼ in. Green clothboard covers. Published by the McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price* $4.50.

It is the purpose of this book to supply engineers, and those preparing to become engineers, with the basic mathematical aids essential to the solution of problems associated with the many new engineering developments.

The fundamental principles that underlie mathematical operations are thoroughly analyzed, and their application is illustrated by many examples. The contents of the book can be appraised by a few of the chapter headings such as: Uniform scales, logarithms as an implement, circles as tools, vectors, imaginary and complex numbers, hyperbolic functions, kinetics of rotation, and kinetics of plane motion. There are also five chapters dealing with differential equations.

More than 250 line cuts are used in the book to illustrate the discussion.

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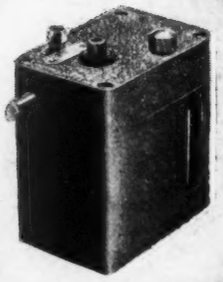

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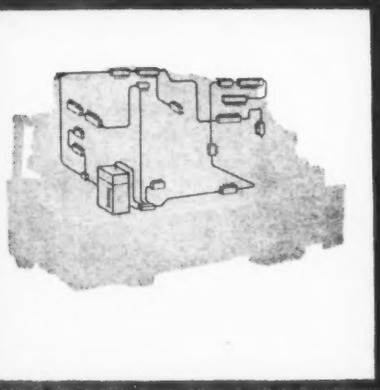

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Torsional Deflection of Hollow Shafts

VICTOR M. KIBARDIN

THE ACCOMPANYING CHARTS can be used to determine the relations between the torsional deflection, applied torque, outside shaft diameter, inside diameter and length of hollow shafts loaded in torsion. The charts are based on the following general equation for the deflection of a hollow shaft, where

θ = angle of twist, rad.
T = twisting moment or torque, lb. in
L = length of shaft, in.
G = shear modulus of elasticity of material
I_p = polar moment of inertia of the section, in.^{4}

$$\theta = \frac{TL}{GI_p} \qquad (1)$$

The problem of determining the deflection or the wall thickness resolves itself into the solution of the above equation for different values of parameters: D/t, the ratio of the outside diameter of shaft to the wall thickness; and L/D, the ratio of shaft length to the outside diameter of shaft.

Chart 1 gives the graphical solution for the torsional deflection of hollow shafts within the following limits:

T = 100,000 lb. in. (constant)
G = 11,000,000 lb. per sq. in.
L/D = 2.0 (constant)
D/t = 0 to 100
D = 1 to 10 in.

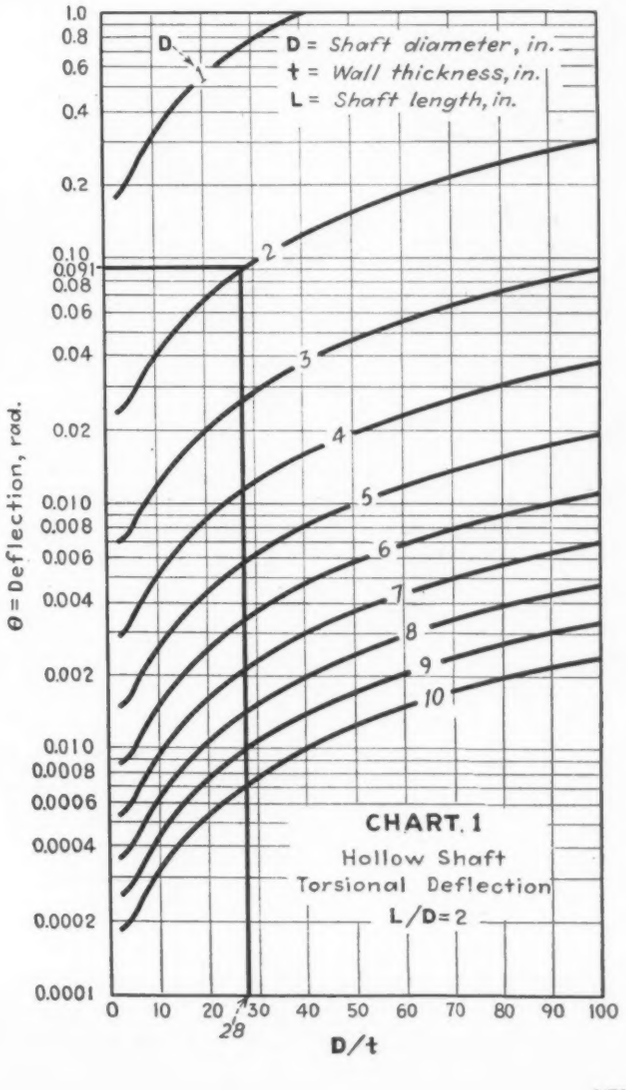
To obtain the torsional deflection of hollow shafts for a given ratio of outside diameter to wall thickness when the design torque, design modulus of shear or the design parameter L/D is different from the value used in constructing the chart, the values of deflection as given by Chart 1 should be multiplied by the following correction factors:

$$\text{Torque correction factor } F_T = \frac{\text{Design torque}}{100{,}000} \qquad (2)$$

$$\text{Modulus of shear correction factor } F_G = \frac{11{,}000{,}000}{\text{Design modulus of shear}} \qquad (3)$$

$$\text{Parameter } L/D \text{ correction factor } F_P = \frac{\text{Design } L/D \text{ parameter}}{2 \text{ (constant)}} \qquad (4)$$

To obtain the ratio of outside diameter to wall thickness for a given torsional deflection when the design torque, design modulus of shear or the design parameter L/D is different from the value used in constructing the Chart 1,



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the given torsional deflection should be multiplied by the reciprocals of factors (2), (3) and (4).

Cross-sectional areas are given in Chart 2 for shafts with different D/t-ratios. Polar moments of inertia are given in Chart 3 for shafts with different D/t ratios. The moment of inertia in reference to a diameter is half the polar moment of inertia.

The heavy lines on the Charts solve the following illustrative problem.

EXAMPLE:

What inside diameter is required for a hollow shaft that is 2 in., O.D., 10 in. long, to obtain a deflection of 0.350 radians under a torque of 160,000 lb. in. Shaft is made of steel having a modulus of shear of 11,500,000 lb. per sq. in. What is the cross-sectional area and polar moment of inertia of the shaft?

SOLUTION:

$$F_T = \frac{160{,}000}{100{,}000} = 1.6$$

$$F_G = \frac{11{,}000{,}000}{11{,}500{,}000} = 0.957$$

$$F_P = \frac{10/2}{2} = 2.5$$

The deflection to use on Chart 1 is then

$$\theta = 0.350\left(\frac{1}{F_T F_G F_P}\right) = \frac{0.350}{1.6 \times 0.957 \times 2.5} = 0.091$$

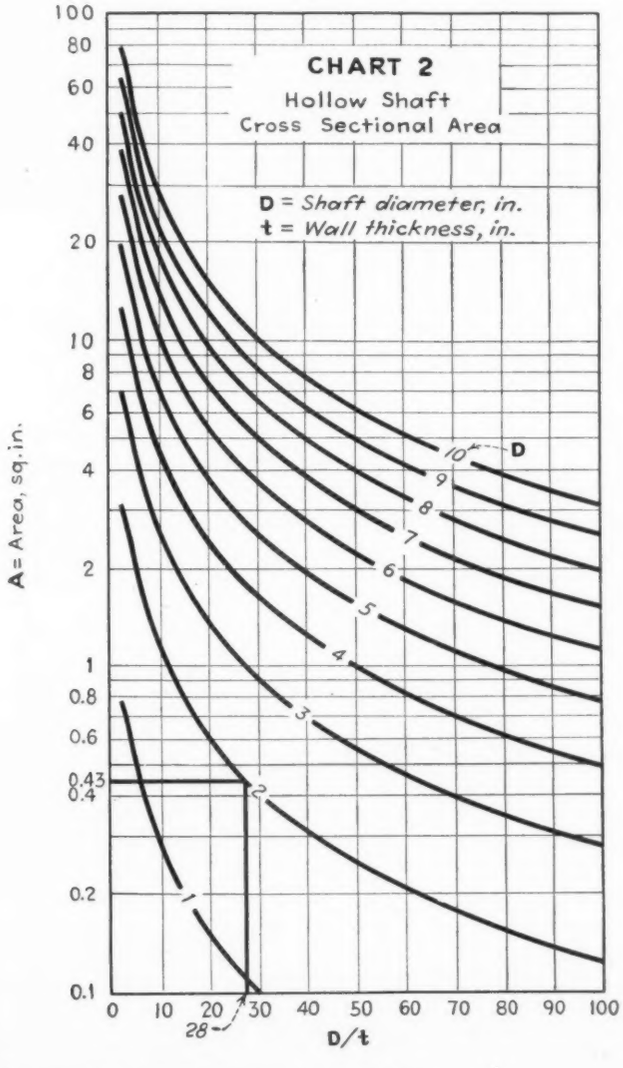
From this value for θ on Chart 1 follow across horizontally to curve of D equals 2. From this point of intersection, follow vertically downward to the abscissa and read D/t equals 28. Then

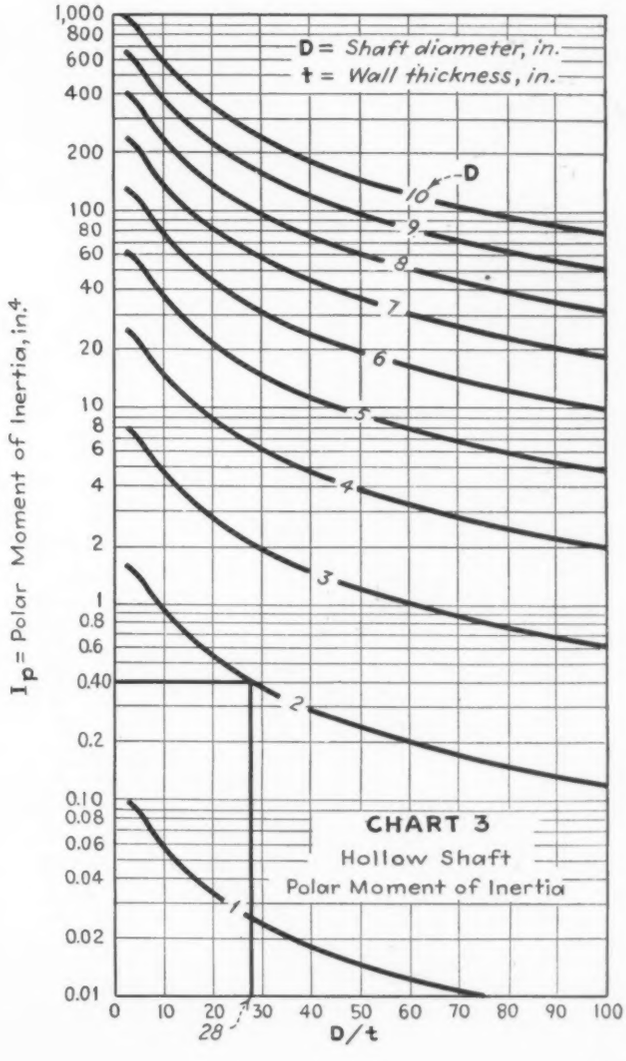
$$\text{Wall thickness } t = \frac{D}{28} = \frac{2}{28} = 0.071 \text{ in.}$$

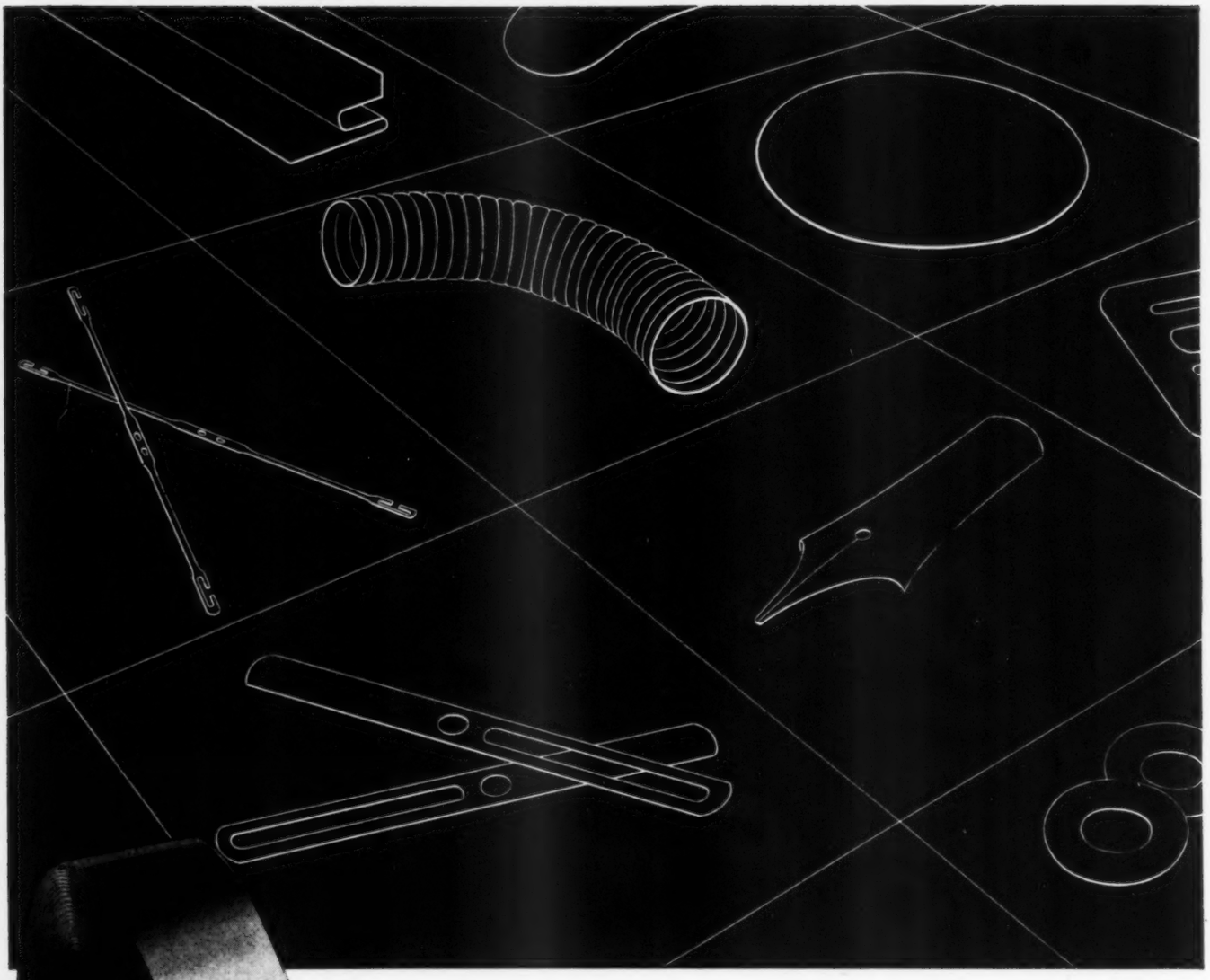
$$\text{Inside dia.} = 2 - 2 \times 0.071 = 1.858 \text{ in.}$$

From Chart 2 using a value of D/t equals 28, for a 2 in. O.D. shaft the cross-sectional area is 0.43 square inches.

From Chart 3 using a value of D/t equals 28, for a 2 in. O.D. shaft, 0.40 in.^{4} is given as the polar moment of inertia.







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NEW MATERIALS AND PARTS

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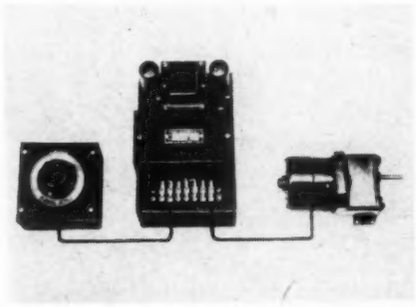
Tubing, Luminous	United States Radium Corp.	182
Valves, Control	Hammel-Dahl Co.	176

Remote Control

Yardeny Labs, Inc., 105-107 Chambers St., New York 7, N. Y.

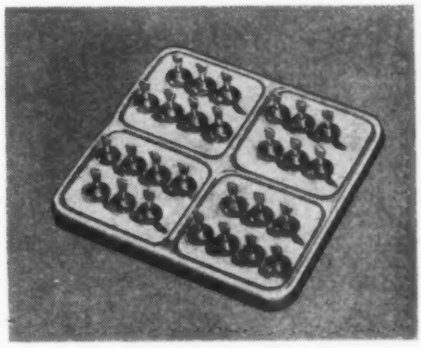
The Synchro-Link is a positioning servo control that positions one or a number of distant motors according to the setting of the control transmitter. It consists of three elements: The master control, the electronic controller, and the load control potentiometer geared to the motor or coupled to the load. Two adjustments provide a sensitivity control, and an anti-hunting control. The unit is designed for use with any reversible motor delivering 1/10 to 35 hp. The controller contacts will handle 15 amp. at 110 volts a.c., or 10 amp. at 220 volts a.c. The Synchro-Link operates on 115 volts, a.c. supply.



Terminal Seals

Hermetic Seal Products Co., 414-418 Morris Ave., Newark 3, N. J.

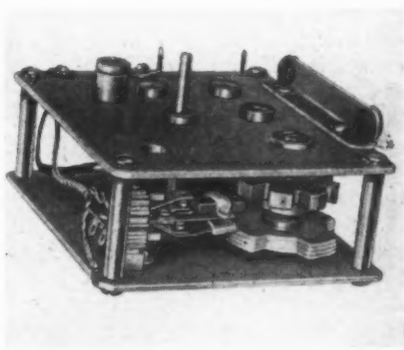
Headers designed with as many terminals as desired molded into a single cover unit can now be made with a new process for providing seals in a combination of a new metal, and glass. The terminals can be arranged with a minimum of spacing in any pattern or combination of voltages. It is claimed that these headers are supplied without any restriction imposed on their eventual use. There is a permanent chemical bond between the glass and the metal. These headers are made with matched coefficients of expansion that will withstand the shock of hot tin dipping. These vacuum tight seals have a resistance of 10,000 megohms between the body and the terminals, or between terminals.



Constant Speed Motor

Amglo Corp., 4234 Lincoln Ave., Chicago 18, Ill.

Approved by the Bureau of Standards, the FCC, and CAA, this d.c. unit is claimed to maintain constant speeds regardless of voltage variation. It is completely self-starting, and attains full speed quickly. Current consumption va-

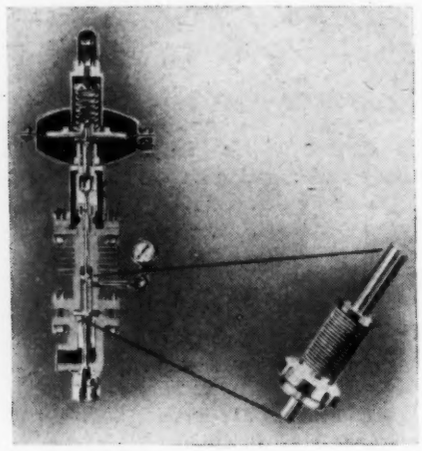


ries from 0.06 to 1 watt, either from battery or d.c. line sources. Shaft speeds can be geared from 1 revolution each 24 hr. to 100 r.p.m. The motor is available for use at 3, 6, 12, 24, 32, or 110 volts.

Control Valves

Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.

The 3000 B series of packless diaphragm control valves utilizes the sealed bellows principle of construction. This design can be used for handling toxic or dangerous fluids; fluids with a high vapor pressure, refrigerants, and whereever stuffing gland leakage cannot be

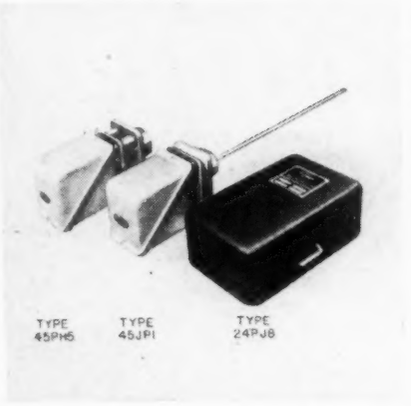


tolerated. The replaceable bellows unit is available in two-ply Type 347 stainless steel, and can be mounted on any size screw end valve from ½ to 1½ in., and flanged end valve from 1¼ to 12 in. This valve can be used for control with any pressure up to 500 lb. per sq. in., over a temperature range of minus 70 to 750 deg. Fahrenheit.

Flame Failure Safeguard

Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.

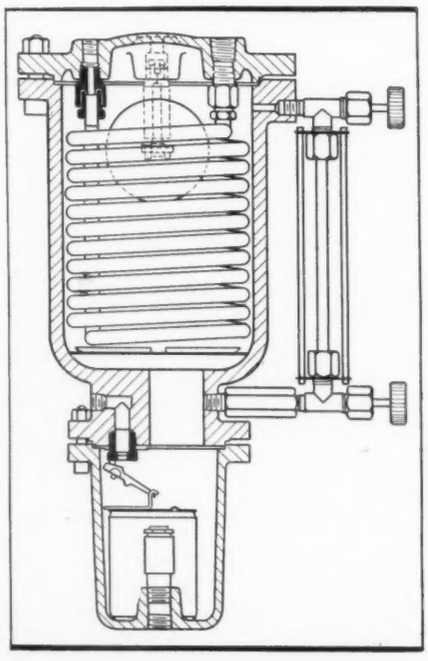
The Fireye Photoelectric Flame Failure Safeguard system is made up of the Photoelectric Scanner Type 45PH5 for monitoring the main oil burner flame, and the Programming Control Type 24PJ8 for programming the oil pump, oil valve, and ignition system. Flame Rod Type 45JP1 may be added to this combination if it is desired to monitor the gas pilot flame as well. Since the scanner contains both the phototube and amplifier tube, no special shielded cable is required between the scanner and programming control. The programming control gives accurate setting of both oil valve delay and post ignition periods in seconds. Timing is accomplished through a synchronous motor. Relay contacts are of heavy duty type capable of handling directly a pump motor of 1 hp. rating.



Refrigeration System Purger

Armstrong Machine Works, 903 Maple St., Three Rivers, Mich.

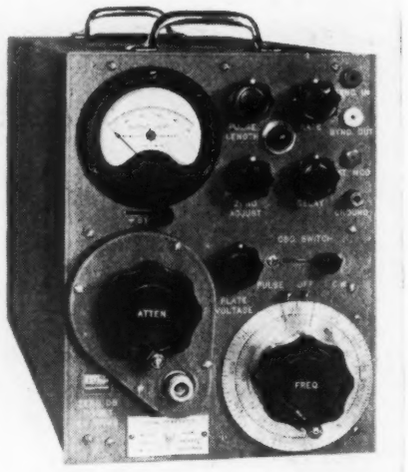
A non-condensible gas purger for refrigerating systems. This unit is essentially the same as older models except that the refrigerating jacket has been replaced by an internal coil. Use of the coil is claimed to increase, by approximately 50 percent, the condensing surface available. A non-condensible gas discharge mechanism is incorporated and the ball float used to actuate the valve is enlarged. This purger is available in two styles: No. 270 with semi-steel body for pressures up to 200 lb. per sq. in., and No. 370 with forged steel body for pressures up to 300 lb. per sq. in. Adaptable to systems of virtually any capacity, and using any commercial refrigerant, the purger is claimed to operate with equal efficiency whether system pressure is above or below atmospheric.



Signal Generator

Hewlett-Packard Co., Palo Alto, Cal.

Within its frequency range of 500 to 1,350 mc the Model 610A UHF signal generator is a practical source of UHF current for general laboratory use. It



can be used as a laboratory standard for determining gain or alignment, antenna data or measuring standing-wave ratios. This instrument will supply known voltages ranging from 0.1 microvolts to 0.1 volt. R-f output can be continuous, amplitude modulated, pulsed, or square-wave modulated. Pulse length can be controlled between 2 and 50 microseconds, and pulse rate is variable from 60 to 3,000 times per second.

Meters

Shurite Meters, 61 Hamilton St., New Haven 8, Conn.

Flush-mounted panel meters of black enameled brass construction, requiring 27/64 in. panel holes, are calibrated for a non-magnetic board. They can be calibrated for steel panels if the over-all size and thickness of the panel are known. The dials are metal, age and moisture resistant, and lithographed in black and white. Two round cases and one rectangular case are available

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1 LOW COST

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3 QUIET

4 LONG LIFE

5 CORROSION RESISTANT

6 UNIT CONSTRUCTION

7 LOAD CARRYING CAPACITY

8 HIGH RESISTANCE TO SHOCK

9 LOW COEFFICIENT OF FRICTION

10 EASY TO INSTALL

11 CONFORMABILITY

12 NATION WIDE SERVICE

LEADING engineers and designers prefer SLEEVE TYPE BEARINGS for numerous reasons. They have learned from experience the many distinct advantages gained when the right bearing is properly installed. In some applications, their reasons are strictly economic, such as low initial cost . . . quick assembly . . . easy replacement. It might be toughness . . . ability to carry heavy loads . . . to withstand shock and impact. Again it is quiet operation . . . smooth, silent performance. It may be precision . . . fine workmanship . . . adherence to close tolerance. It might be all of these characteristics . . . and more.

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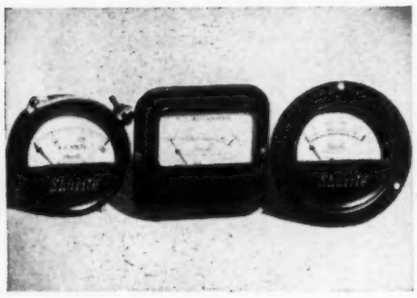
SLEEVE BEARING HEADQUARTERS

BRANCHES IN 18 INDUSTRIAL CENTERS



in a.c. and d.c.; ammeters, millimeters, voltmeters and resistance meters. All d.c. meters are polarized-vane, solenoid type; all a.c. meters are double-vane, repulsion type. All meters are accurate within 5 percent.

Stainless-Clad Steels

Lukens Steel Company, Coatesville, Pa.

To achieve the corrosion resistance and product protection of solid stainless steel, a light layer of cladding material is bonded to a backing plate of carbon or low alloy steel. The cladding, generally of stainless steel of types 304, 316, 347, 410 and 430, is usually 10 percent of total plate thickness, but any percentage from 5 to 50 percent can be obtained. These clad steels exceed the minimum shear strength requirements of the ASME Code of 20,000 lb. per sq. in. Specifications of both the stainless steels and backing plates can be widely varied to meet chemical and physical requirements.

Caster

Aerol Co., 1823 E. Washington Blvd., Los Angeles 21, Cal.

This aluminum alloy caster is supplied with an oil-resistant rubber tire, shake proof king pin, and sufficient offset for quick trailing. The thrust and king pin bearings are factory greased and eliminate axle wear and side play. The caster is available in various sizes in either swivel or rigid types.

Midget Neon Pilot Light

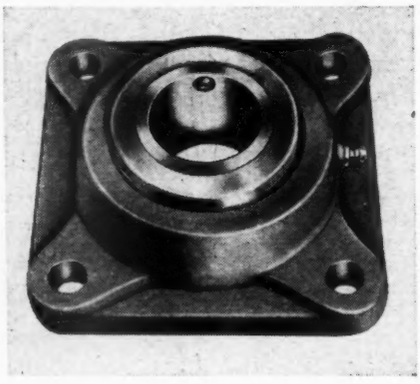
Industrial Devices, Inc., 22 State Road, Elgewater, N. J.

Housed in a heavy metal casing, this lamp consumes under 1/10 watt and operates at any voltage from 75 to 250 a.c. or d.c. The unit, in polished chrome plating, requires two 13/64 in. holes in panel or mounting surface to take the mounting studs and nuts. The standard studs are ⅜ in. long but other lengths are available. The 4 in. insulated tinned leads for the two connections pass through the mounting studs. There are no spring contacts. The unit is shock- and vibration-proof.

Flange Bearings

Dodge Manufacturing Corp., Mishawaka, Ind.

This self-aligning ball bearing flange unit has deep groove precision ball bearings with long inner race, improved

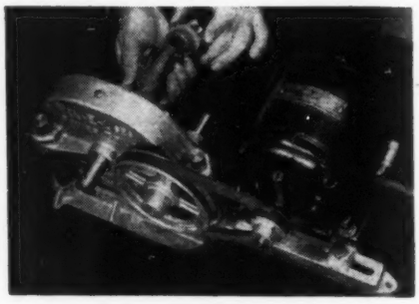


labyrinth seals, and is suitable for mounting against vertical or horizontal frames and supports. The back face of the housing is machined, and filling slots are located on the back surface to provide added protection against external dust and dirt.

Power Drive

The Flinchbaugh Co., 750 S. Court St., York, Pa.

This variable speed power drive is designed to meet any fractional hp. drive requirement. It has a range from 20 to 750 r.p.m. with 1725 hp. r.p.m. motors. The aluminum base and housing weigh 12 lb. Either direction of



shaft rotation can be obtained by mounting right or left on base. Power drive does not depend on the direction of the motor rotation.

Tracing Material

Eastman Kodak Co., Rochester 4, N. Y.

Known as Kodatrace, this translucent tracing material is made of safety-base film, tinted blue to reduce eye strain. It has a mechanically matted surface, without a texture pattern, that is suitable for use with pencil or ink. Changes and erasures can be made easily. Drawings on this material can be used as originals for photographic printing. No special storage precautions are required for Kodatrace, and it has no special fire hazards. Supplied in rolls 22 yards long and either 36 or 42 in. wide, this material is available in two thicknesses: 0.0045 and 0.0075 inches.

Switches

Grayhill, 1 N. Pulaski Rd., Chicago 24, Ill.

This rotary switch measures ¾ in. in diameter, 13/32 in. in depth, and has a contact pressure of 2½ lb. Known as the Series 5000 Roto Switch, it can be used in almost any circuit combination up to 5 amp., breaking up to 1 amp. at 110 volts. Having 360 deg.

Short on Materials?
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Lustron
A MONSANTO PLASTIC
80 MILLION LBS. IN '47!
Here's welcome news to you many manufacturers who can't get your products on the market today for lack of raw materials:
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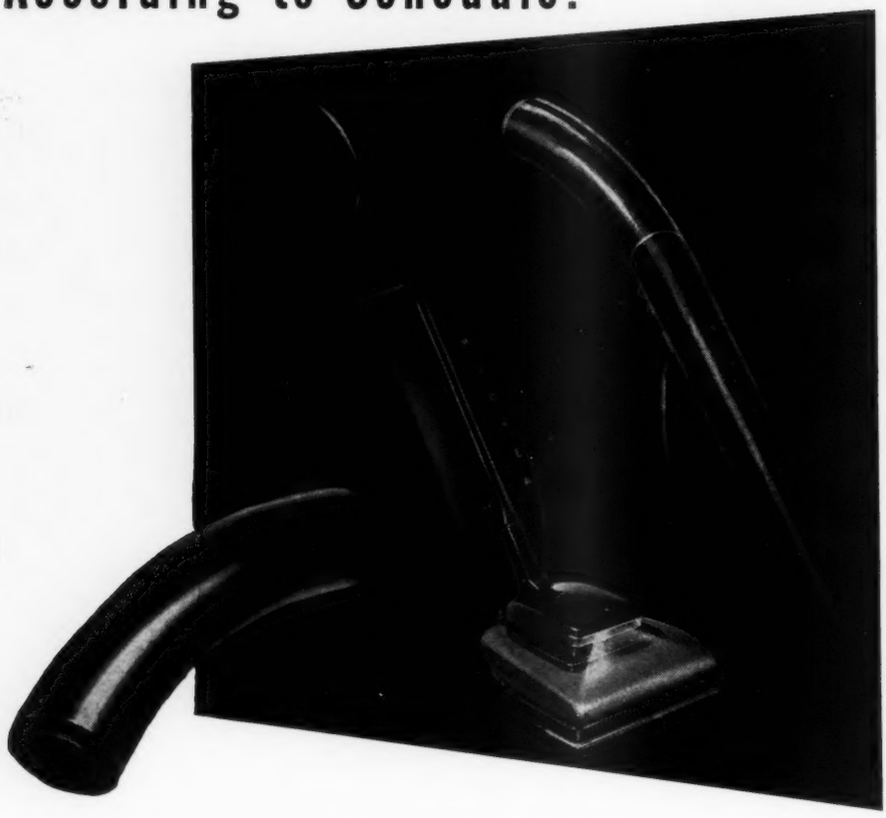

MACOID'S extensive manufacturing facilities are an important asset to MACOID customers in production scheduling. On a plastic handle for the Hoover Cleaner, for example, MACOID has been able to keep steady pace with the intensified post-war demand for this popular home appliance.

MACOID facilities for solving design problems, too, are likewise illustrated by this job. Specifications called for a cylindrical shape formed on a radius with uniform wall thickness throughout. To complete this job economically and in volume, MACOID engineers devised some of their own equipment. The result (shown above, ½ actual size) is a light-weight, comfortably-shaped handle that exactly meets the requirements.

Whether your plastic problem be one of material, design, assembly, or production, MACOID engineers and facilities are equipped to be of service.

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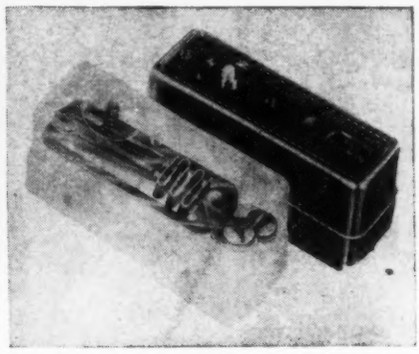
EXTRUSION AND INJECTION MOLDING

rotation in either clockwise or counter-clockwise direction, the switch can be moved from one of its 10 positions to another by turning throughout the least number of positions. If desired, stops can be placed to allow rotation only through a given number of positions. The switch is available in both shorting and non-shorting types, with shafts either for knob or screw adjustments.

Snap-Action Switch

Unimax Switch Corp., 460 *West* 34*th Street, New York* 1, *N. Y.*

Known as "Unimax," this switch has a moving member of heat-treated beryllium copper, with tongue ribbed for maximum stability. The folded flat spring section exerts contact pressure and produces instant traverse. Non-rotatable actuator button assures applica-

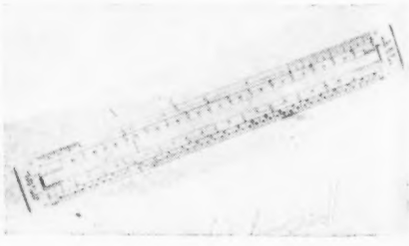


tion of actuating force to the same spot on tongue throughout life of switch. Contacts are silver, laminated on copper; moving contact has low mass for minimum contact bounce. For convenience in production assemblies, one mounting hole is elongated. Overall dimensions of the molded phenolic case are $1\frac{3}{16} \times \frac{1}{16} \times \frac{3}{16}$ in. Electrical ratings: 15 amp 125 volts; 5 amp. 250 volts; ½ hp., 115-460 volts 60 cycles; all units single-pole, double-throw.

Drafting Scale

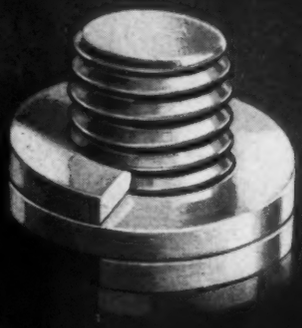
Stewart-Jackson Instrument Co., 215 *West 7th St., Los Angeles* 14, *Cal.*

Known as the "Vant Rule," this unit has eight different scales on one side. The scale need not be turned over for calibrations of ⅛, ¼, ⅜, ½, ¾, 1,



SPRING LOCK NUT

REVOLUTIONARY NEW FASTENER



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ELIMINATES ONE OPERATION

SURE LOCK FOR BOLT

SPEEDS PRODUCTION

EASILY ASSEMBLED

CUTS TIME . . . MATERIAL . . . COSTS

Here's one of the greatest advancements ever made in the field of fastening devices. A new and revolutionary fastening device developed in the engineering and research laboratories of Garrett's to meet an urgent post-war need.

It replaces the conventional nut and in one assembly operation assures a positive locking action on the bolt. The Diamond G Spring Nut has all the advantages of a regular nut and is adaptable for use in "hopper-feeders" and various types of power wrenches. Because of precision manufacturing it has greater gripping power on threads of screw or bolt and therefore resists loosening. This new Spring-Nut is priced to offer a tremendous saving over conventional nuts and other fastening devices.

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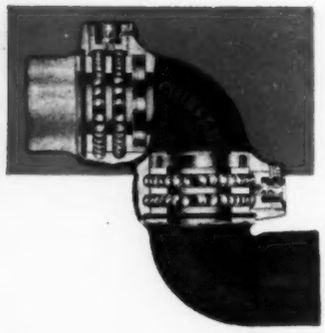
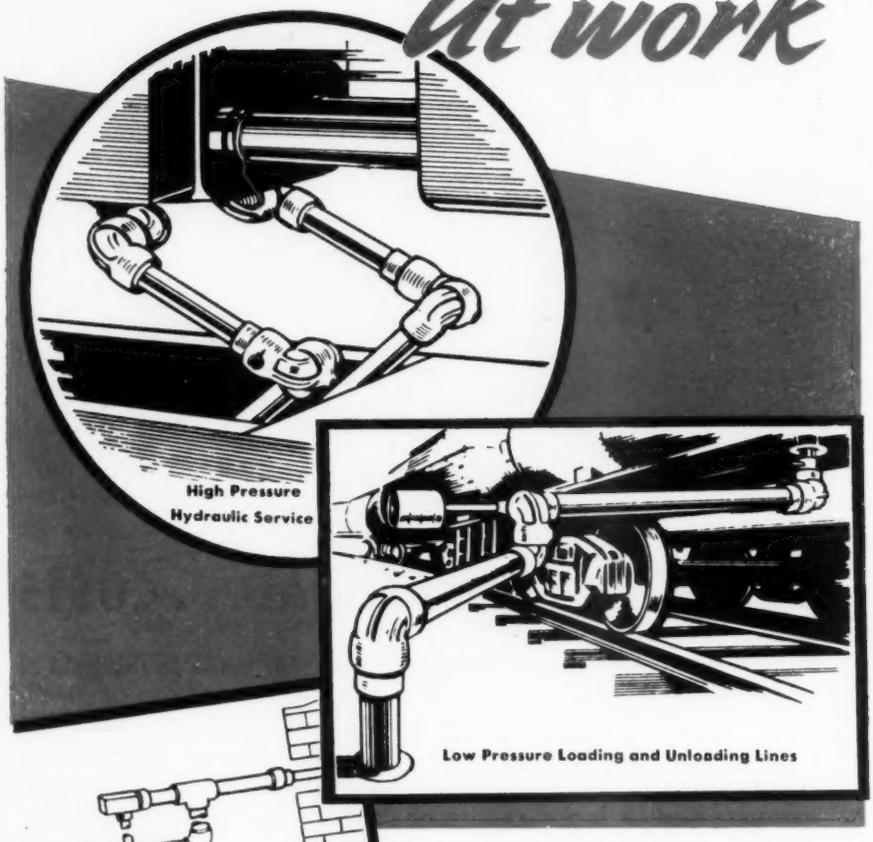


BALL BEARING SWIVEL JOINTS

At work



Look around you and you will see CHIKSAN *Ball-Bearing* Swivel Joints at work in many different applications ... from low pressure loading and unloading lines to high pressure hydraulic equipment and under high temperatures on boilers and open hearth furnaces. CHIKSAN Swivel Joints are made in over 500 different Types, Styles and Sizes... for pressures from 300 psi to 12,000 psi and temperatures to 500° F... for full 360° rotation in 1, 2 and 3 planes... with threaded or flanged ends or bored for welding. Write for CHIKSAN CATALOG No. 45.

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CHIKSAN — BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES

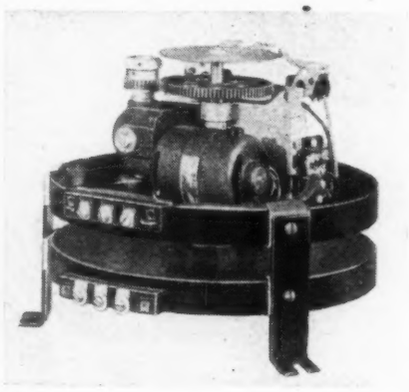
CHIKSAN COMPANY
BREA, CALIFORNIA
New York 7 Houston 2

1-½, and 3 in. per foot. The Vant Rule is of clear, heavy, 0.125 in. plastic with calibrations and numerals in red to facilitate reading against black and white drawings or blue prints. Overall length is 13½ in. and all edges are beveled.

Motor Drive

Ward Leonard Electric Co., Mount Vernon, N. Y.

This motor drive unit is designed for remote and automatic operation of single or multiple stamped steel rheostats controlling generator voltages,



motor speeds, lamp intensities, and other rheostat applications. Available for a.c. and d.c. 115 or 230 volt operation, this unit is constructed on a 13 in. dia. steel plate and intended for mounting on extended rheostat feet.

Luminous Tubing

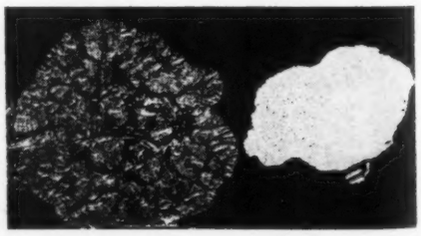
United States Radium Corp., 535 Pearl St., New York 7, N. Y.

This tough, semi-transparent, moisture- and acid-resistant plastic tubing, ¼ in. O.D. and 3/16 in. I.D., is uniformly coated on the inside with a radioactive material that is visible in complete darkness.

Enamel Stripper

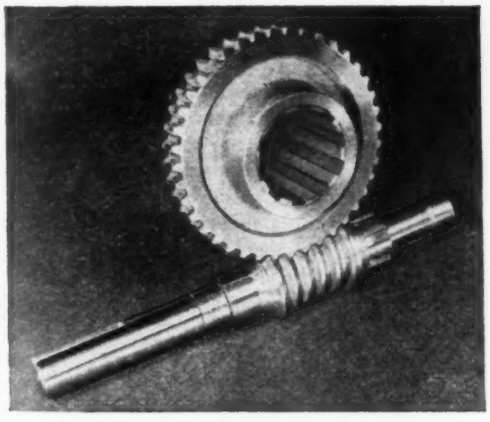
Enthone, Inc., Dept. PE, 442 Elm St., New Haven, Conn.

Recommended for removal of enamel, and other coatings, from parts too large for immersion, this stripper is a slightly viscous liquid that can be



LET STANDARD CONE-DRIVE GEAR SETS CARRY THE LOAD

they'll carry more- and in less space.



Just check the ratings of some of the Cone-Drive standard matched gear sets shown in this table against the capacity of other gears. That's right. Cone-Drives will handle several times the load of other gears of the same size. What's more you can get quick delivery—standard gear sets are carried in stock in blank form. They require only final gear cutting.

For complete information on standardized Cone-Drive gear sets write today for Bulletin #700.

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MICHIGAN TOOL COMPANY
7171 E. McNichols Road, Detroit 12, U. S. A.

HORSEPOWER RATINGS AT 100 & 1750 PINION RPM

2 inch Center Distance		3 inch Center Distance		4 inch Center Distance		5 inch Center Distance		6 inch Center Distance		RATIO	8 inch Center Distance		10 inch Center Distance		12 inch Center Distance		15 inch Center Distance		18 inch Center Distance	
100	1750	100	1750	100	1750	100	1750	100	1750		100	1750	100	1750	100	1750	100	1750	100	1750
.35	2.96	1.24	9.04	3.00	19.8	6.07	37.0	10.4	59.1	5:1	24.4	119.2	45.8	208.	77.6	336.				
.21	1.95	.75	6.11	1.81	13.4	3.65	24.47	6.35	40.4	10:1	14.7	82.6	28.0	145.	47.1	217.	86.0	410.	133.	632.
.15	1.40	.53	4.39	1.27	9.64	2.58	18.09	4.46	29.1	15:1	10.4	61.2	19.8	105.	33.8	163.	60.5	299.	91.	446.
.11	1.10	.40	3.40	.98	7.5	2.00	13.96	3.39	22.5	20:1	7.92	46.9	15.2	81.6	26.6	131.	45.3	232.	69.	361.
.09	.86	.33	2.77	.79	6.03	1.60	11.2	2.77	18.4	25:1	6.47	38.4	12.3	66.9	21.4	106.	36.6	189.	55.5	296.
.08	.73	.27	2.32	.65	5.06	1.34	9.47	2.32	15.8	30:1	5.42	32.2	10.2	56.0	17.9	89.0	30.0	161.	46.2	248.
.06	.55	.21	1.75	.50	3.79	1.01	7.13	1.75	11.8	40:1	4.1	24.4	7.77	42.4	13.6	67.2	22.2	122.	34.2	186.
		.17	1.40	.39	3.07	.809	5.70	1.40	9.45	50:1	3.28	19.5	6.22	33.9	10.9	53.8	18.0	95.8	27.6	150.
				.33	2.54	.675	4.75	1.17	7.87	60:1	2.74	16.2	5.20	28.7	9.00	45.5	12.7	80.6	21.5	125.
						.58	4.08	1.00	6.75	70:1	2.34	13.9	4.45	24.6	7.72	39.0				

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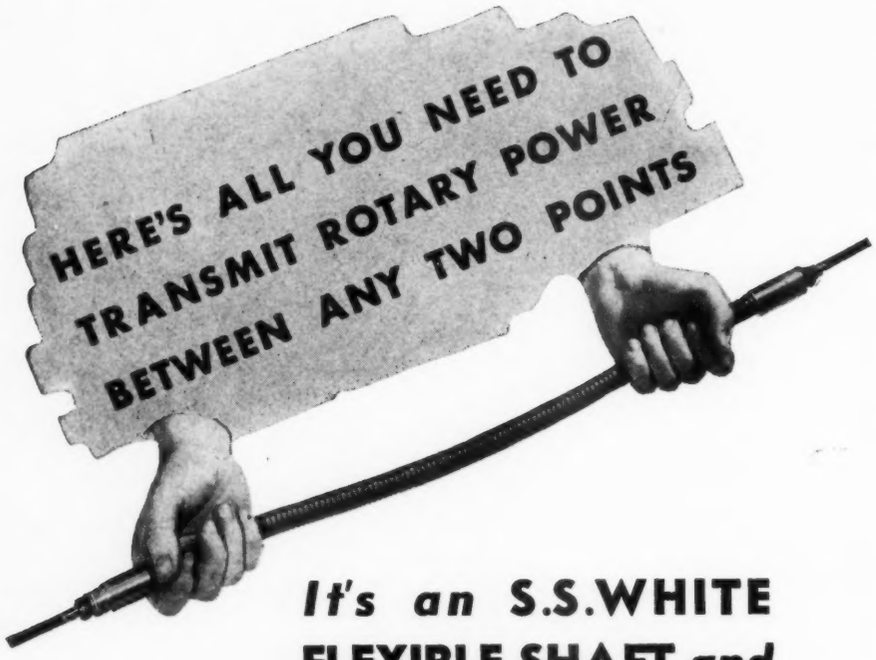

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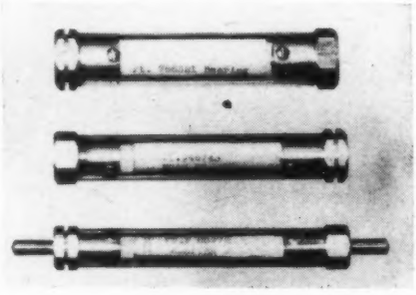
brushed, sprayed or applied by dipping. It contains a non-waxy evaporating retardent that keeps it on the work until the action is completed. Stripper produces a wrinkling action so that the coating can be brushed, wiped or scraped away. Left half of cut shows wrinkling action 30 sec. after application. This stripper works on most synthetic enamels as well as certain nitrocellulose coatings. It is not satisfactory for linseed oil paints, phenol-formaldehyde enamels, or vinyl-type coatings.

Gage Handle

Industrial Development Associates Inc., 223 Spruce St., Bloomfield, N. J.

Known as Vis-U-Trol, this unit consists of a transparent plastic tube into the ends of which are inserted steel gage ends. These gage ends are held in place by two shallow-type fillister head

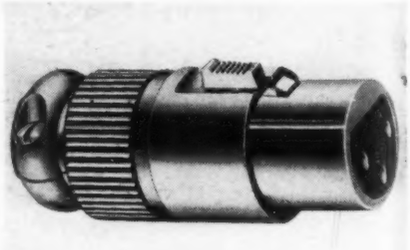


screws that come flush with the outside of the plastic tube. Data, after being typewritten on the proper size card, can be placed into the tube and the screws inserted. The screw heads are sealed to prevent tampering with the record card. The gage ends are hexagonal to prevent the assembled gage from rolling if placed on a flat surface.

Plugs

Cannon Electric, 3209 Humboldt St., Los Angeles, 31, Cal.

Steel shell plugs that will mate with the standard "XL" microphone connector series, have an integral clamp to hold cable with entry sizes from ¼ to 5/16 in. The socket insert assembly carries a latch-locking device. The plug is finished in bright nickel,



Cost of machine frame reduced 50% by change to welded design

BY LOUIS FAULB, PRESIDENT
KLEEN-KUT MANUFACTURING COMPANY
CLEVELAND, OHIO

Production cost of the frame of the Kleen-Kut meat saw manufactured by our company has been reduced more than 50% by redesigning it for fabrication by arc welding. The former design and the latest welded design are shown in Fig. 1.

The new design has reduced machining operations 60%, has made the machine six times as rigid, cut its weight from 550 to 350 pounds, and has doubled the production output of the same floor area.

The changeover to all-welded design was an evolutionary process over an 18-month period.

We started with the table frame shown in Fig. 3, and the cost reduction encouraged us to redesign the whole machine. Since our original all-welded design, we have made 40 improvements. If we had used conventional fabricating methods, 40 modifications or complete changes in patterns would have been necessary. Open views of the original welded design and the latest welded design are shown in Fig. 2.

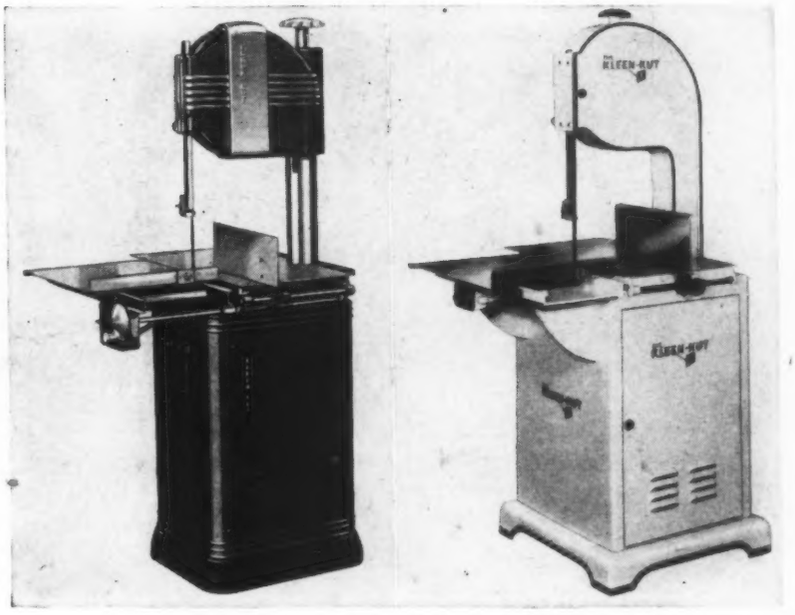


Fig. 1. Saw of former conventional design (left) and all-welded design (right).

IMPROVES THE PRODUCT

Welded design has increased the saw's overall rigidity and strength. The top pulley support, subject to considerable stresses, was stiffened by simply welding a 32-inch length of angle vertically inside the housing. Rigidity was further aided by widening the main frame to the full length of the base and redesigning the door.

Adjusting the saw blade tension in the former model required moving the entire head of the unit up or down, which took too much time. In the new design this adjustment is made by simply turning a rod. To incorporate this feature in the former design would have meant an excessive amount of machining.

INTERMITTENT WELDS USED

The new saw frame is made largely of formed plates, reinforced at strategic stress points with gussets and cross-braces. A minimum of material and welding is used, most parts being fused with intermittent welds like those in the table frame (Fig. 3). This type of welding obtains proper strength, avoids distortion and speeds production.

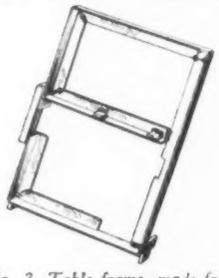


Fig. 3. Table frame, made from angles. This is the first part that was changed to welded design.

The table frame is constructed of 1½-inch angles with ½-inch bearing brace. The machine base consists of four ¼-inch plates joined by fillet welds in open corner joints. The main stand is 5/16-inch-thick steel sheet with inside fillet joints. Bearing and pin bosses are solid welded into the structure. Hinged covers are 14 gauge steel sheet.

Wherever possible, welding is done on the inside of the joint to give a smooth exterior appearance. Because materials are light-weight, all parts can be easily handled for bench-welding.

The reduction in machining operations has enabled us to double our production within the same floor area. Materials-procurement has also been simplified. Previously we ordered parts from seven outside firms; now we make them all in our own plant with simple, low-cost production facilities.

In approaching redesigning problems, our engineers have been aided by the Studies in Machine Design issued periodically by The Lincoln Electric Company. These are available free to engineers and designers who write The Lincoln Electric Company, Dept. 362, Cleveland 1, Ohio.

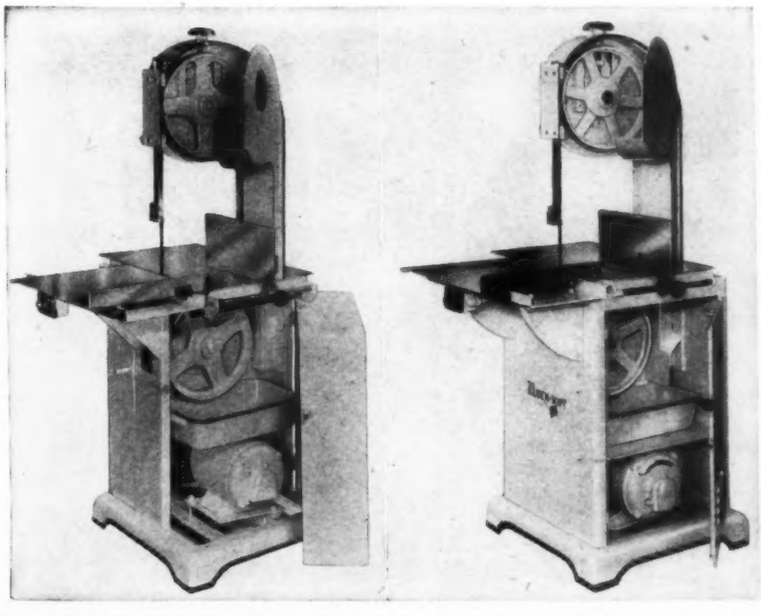
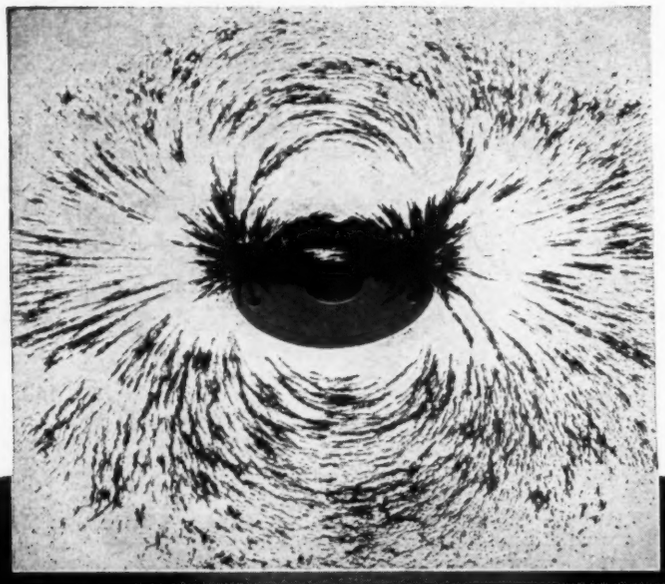


Fig. 2. Original welded design (left) and latest welded design (right) with covers open to show interiors.

(Advertisement)



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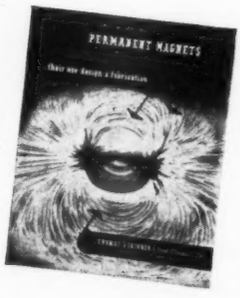

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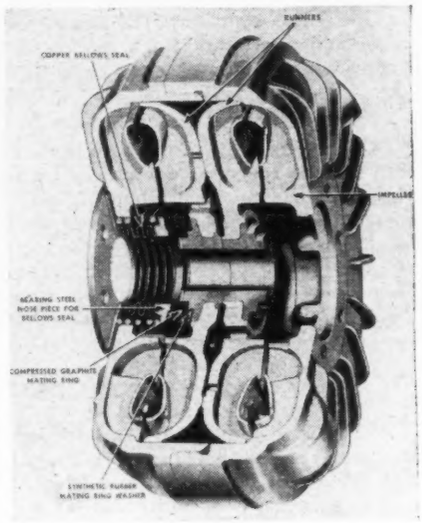
but other types of finishes are available. The plugs can be used in all circuits not exceeding a 15 amp. rating, and the minimum flashover voltage of 1500 volts, while carrying a working voltage of 250 volts.

Hydraulic Couplings

Twin Disc Clutch Co., Rockford, Ill.

Designed for use with induction motors and small internal combustion engines, these couplings are available in sizes ranging from one to 25 hp., at 1,800 r.p.m. These couplings are claimed to prevent stalling, eliminate the need for

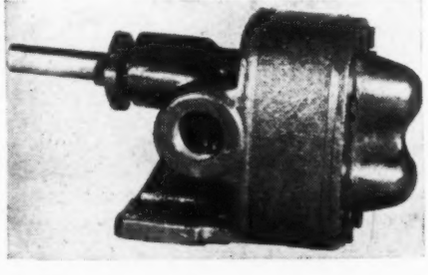


shear pins and permit the reversing of electric motors at full-load speed without high current surges. Both the impeller and the runner are lightweight aluminum castings. A cast iron insert forms the hub of the driven member, taking the drive to the output shaft. Stamped steel core rings in both the impeller and the runner form the hydraulic circuit.

Rotary Pumps

Worthington Pump and Machinery Corp., Harrison, N. J.

Available in six sizes with either foot or flange mountings, these general service units have capacities to 51 gal. per min. at 100 lb. per sq. in. Constructed



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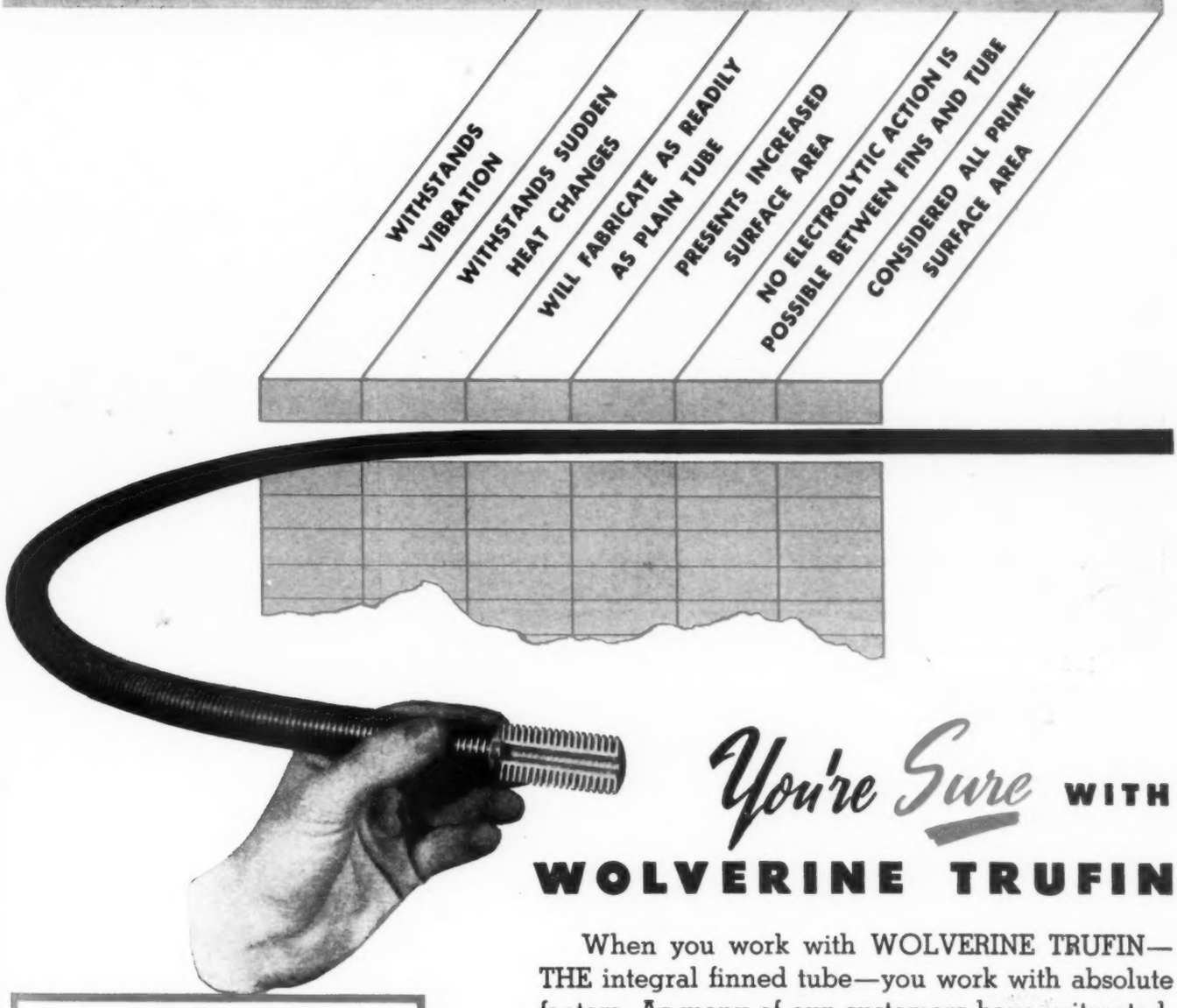
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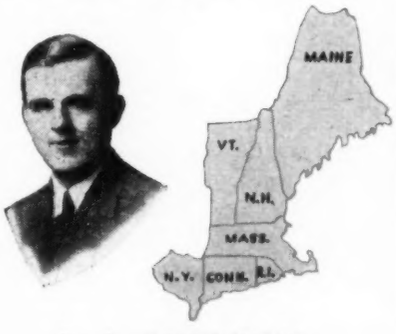

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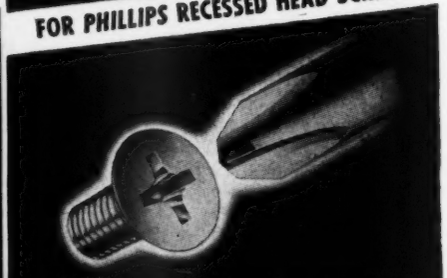

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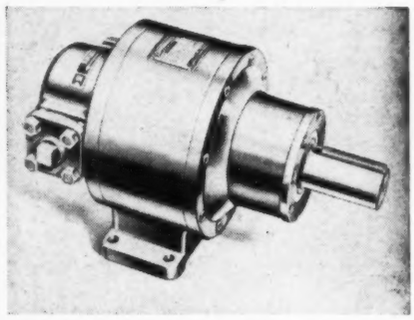
with four bearings, special herringbone rotors, and with or without unloader relief valves, all models are suitable for direct coupling to electric motors. A built-in pressure, lubrication system is claimed to eliminate product contamination. These pumps will operate successfully with light or very viscous liquids.

Hydraulic Pumps

Superdraulic Corp., Miller at Ford Rd., Dearborn, Mich.

Measuring 6 in. in diameter, 11 in. in length and weighing 35 lb., this unit is capable of delivering 5,000 lb. per sq. in. in continuous duty service. The single bank of radial plungers delivers 3



gal. per min. at 1,800 r.p.m. or 2 gal. per min. at 1,200 r.p.m. The pump is claimed to have a high volumetric efficiency.

Counters

The Durance Mfg. Co., 1938 N. Buffum St., Milwaukee 1, Wis.

These double-deck rotary and stroke counters are known as the "N" series. The aluminum case and front and back covers have louvers for easy reading. Rotary models are double worm drive for smooth action and high speeds. Stroke models are designed so that the upper row is chain driven for quiet, easy operation at high speeds. Predetermined models have a simplified switch mechanism for light operations and positive switch action at the predetermined count.

Accumulator

Greer Hydraulics, Inc., 454 18th St., Brooklyn 15, N. Y.

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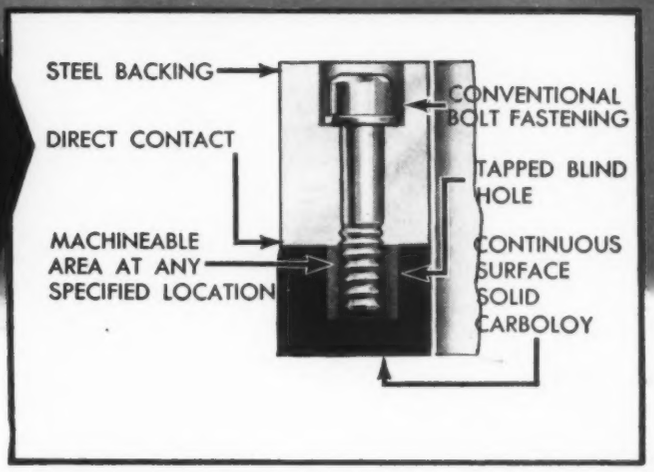

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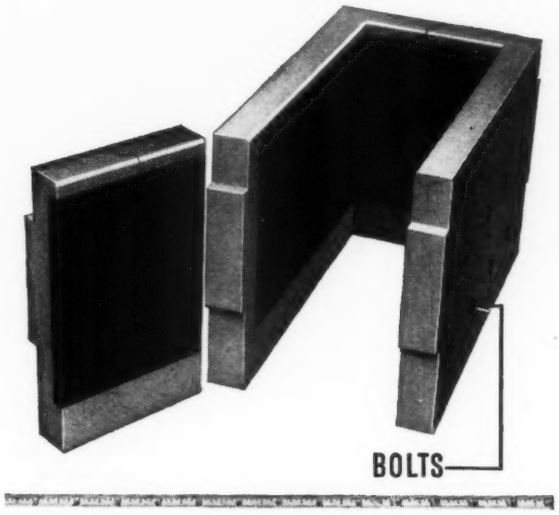

TYPICAL WEAR APPLICATION shown here illustrates how the new method makes possible attaching large sections of wear-resistant Carboloy without use of "through-holes" thereby obtaining a continuous uninterrupted surface. Carboloy section shown here measures 6⅜" x 9½.

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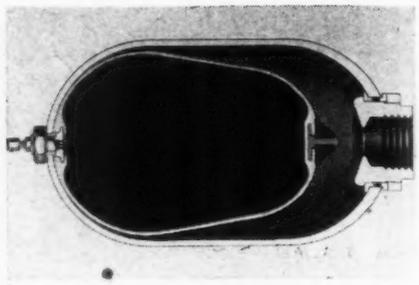
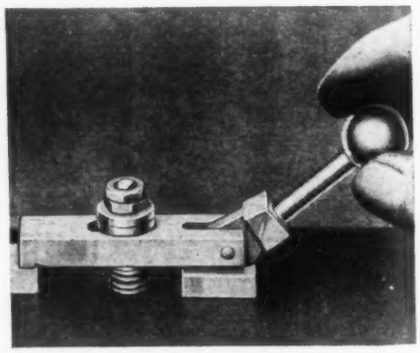


an integrally molded conical-shaped metal plug on the other end for sealing the shell at the end of the oil discharge cycle. This plug eliminates direct contact between the bladder and the outlet plug. The bladder will withstand operating temperatures from minus 40 to 200 deg. F. The volumetric efficiency of this design, in systems operating at pressures as high as 3,000 lb. per sq. in. runs as high as 97 percent with unrestricted flow up to 50 gal. per min., without appreciable pressure drop.

Clamps

West Point Manufacturing Co., 19625 Merriman Court, Farmington, Mich.

A series of small fixture clamps consisting of 4 styles for holding small work pieces. The clamp strap is



2½x⅝x⅜ in., and has spherical washers with ground radii to compensate for irregularities in the work. These clamps are made of heat treated steel and are cadmium plated.

Motor Transmission

Western Mfg. Co., 3400 Scotten Ave., Detroit, 10, Mich.

This two-speed transmission unit will give any one desired speed reduction up to 6.25 to 1 and can be used to replace two-speed motors. Units for use on motor frames, Nos. 224, 225, and 254 are mounted upon flanged-type, end shields and can be swiveled about on the face of the flange to move shifting lever assembly into most convenient position of three: Two horizontal,

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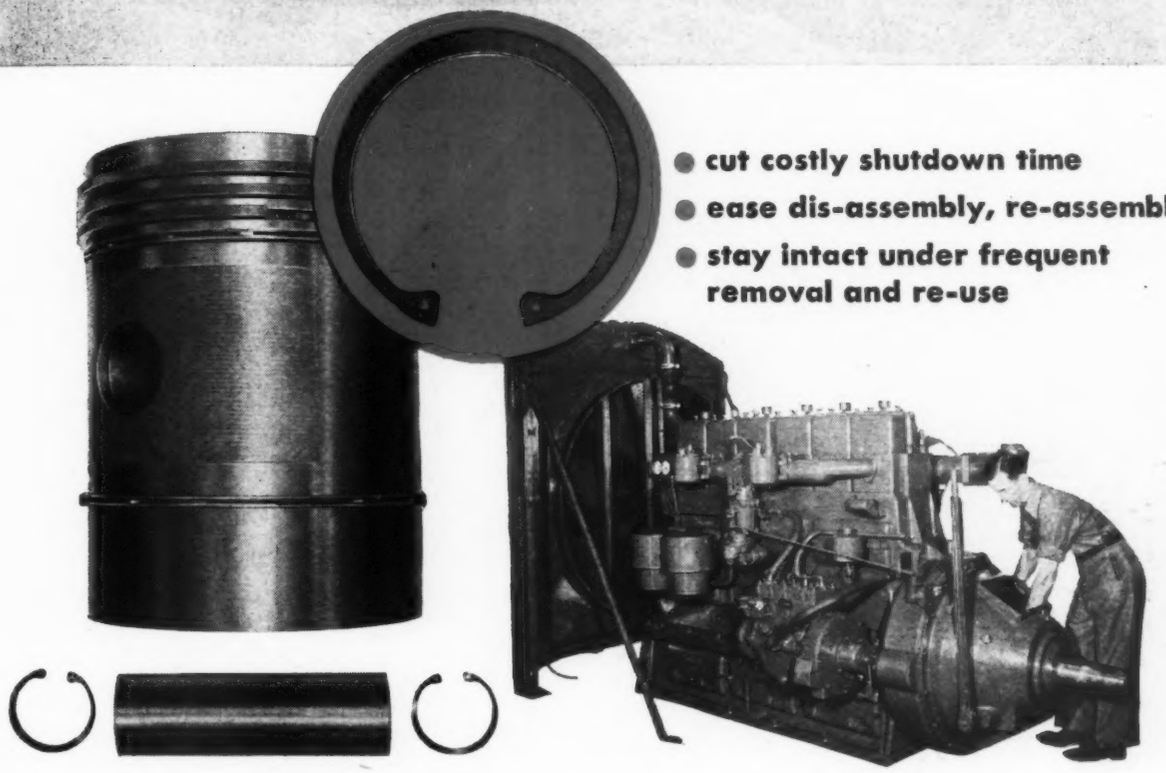

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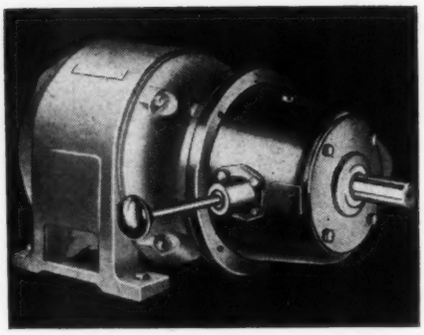
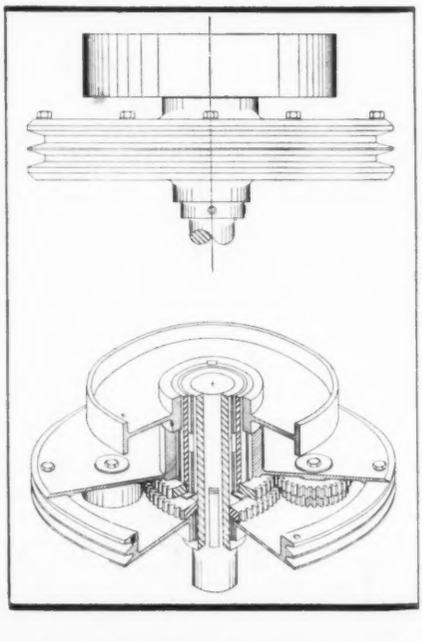


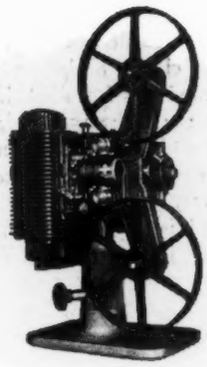
and one vertical. The shifting lever can be put in three places giving direct motor speed, neutral point, and the reduction of the unit. Standard reductions are: 1½ to 1; 2 to 1; 3 to 1; and 4 to 1. In the larger sizes the units are made with modified base mountings corresponding with legs of the motor frame.

Speed Reducer

Hart Engineering & Sales Co., 2015 W. Clybourn St., Milwaukee, Wis.

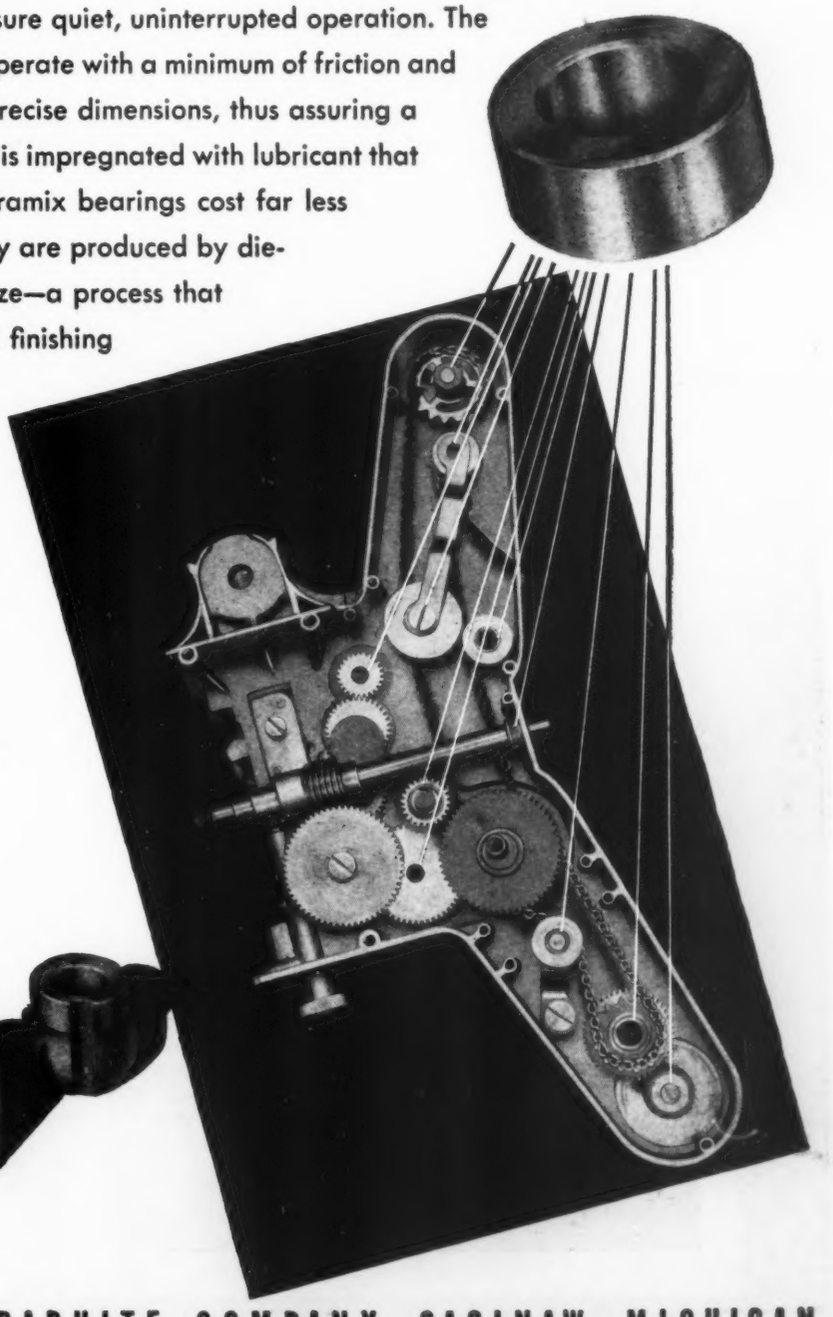
Operating on the inside of a V-belt sheave, this unit replaces gear boxes, gear head motors, and other types of speed reducers. Various speed reduction ratios up to 600:1 can be built into the unit and applied from the motor to the driven machine. No extra sheaves are required. The output shaft extends through the reduction pulley and all gears are inclosed within the sheave in a bath of oil. In addition to a continuous drive model, the pulley can be specified for single or double clutch brake action. Two-speed control in either direction, or one forward and one reverse without changing the rotation of the pulley, can be obtained with the double clutch brake model. No





Gramix bearings reduce noise and wear to an absolute minimum in Revere 8 mm. film projector

If you're looking for a way to make your mechanical products operate more quietly and dependably — and at the same time decrease your production costs — you may find the answer in Gramix metal powder parts. The Revere Camera Company of Chicago did. This firm is equipping its latest type motion picture projector with Gramix bearings to insure quiet, uninterrupted operation. The eleven tough little Gramix bearings operate with a minimum of friction and noise because 1) they are made to precise dimensions, thus assuring a close fit, and 2) their porous structure is impregnated with lubricant that will last the life of the projector. Gramix bearings cost far less than machined bearings because they are produced by die-pressing powdered metal to exact size—a process that eliminates expensive machining and finishing operations. Gramix bearings have perfect bearing surfaces. They can be manufactured to almost any size, shape or dimension. Send us sketches or prints of your products. Our engineers will show you where Gramix bearings, washers, seals, gears, or other parts will improve mechanical performance and save you money.



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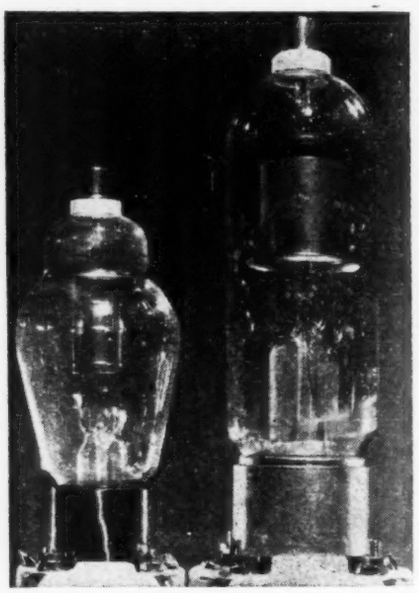
separate engine clutch is needed when either a single clutch brake or double clutch brake model is installed, because the shaft of the driven machine remains neutral and the sheave runs free until the clutch brake is engaged. An automatic safety release to disengage on an overload is obtained by adjusting the clutch brake at any desired load.

Electron Tubes

Eitel-McCullough, Inc., San Bruno, Cal.

Known as Eimac type 866A and 872A, these mercury vapor rectifier tubes are directly inter-changeable with types 866A/866 and 872A/872 of other manufacture. Type 866A/866 operates with

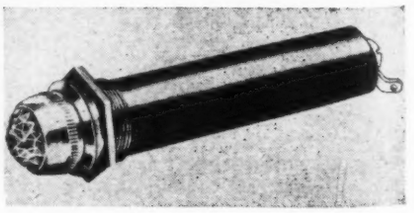


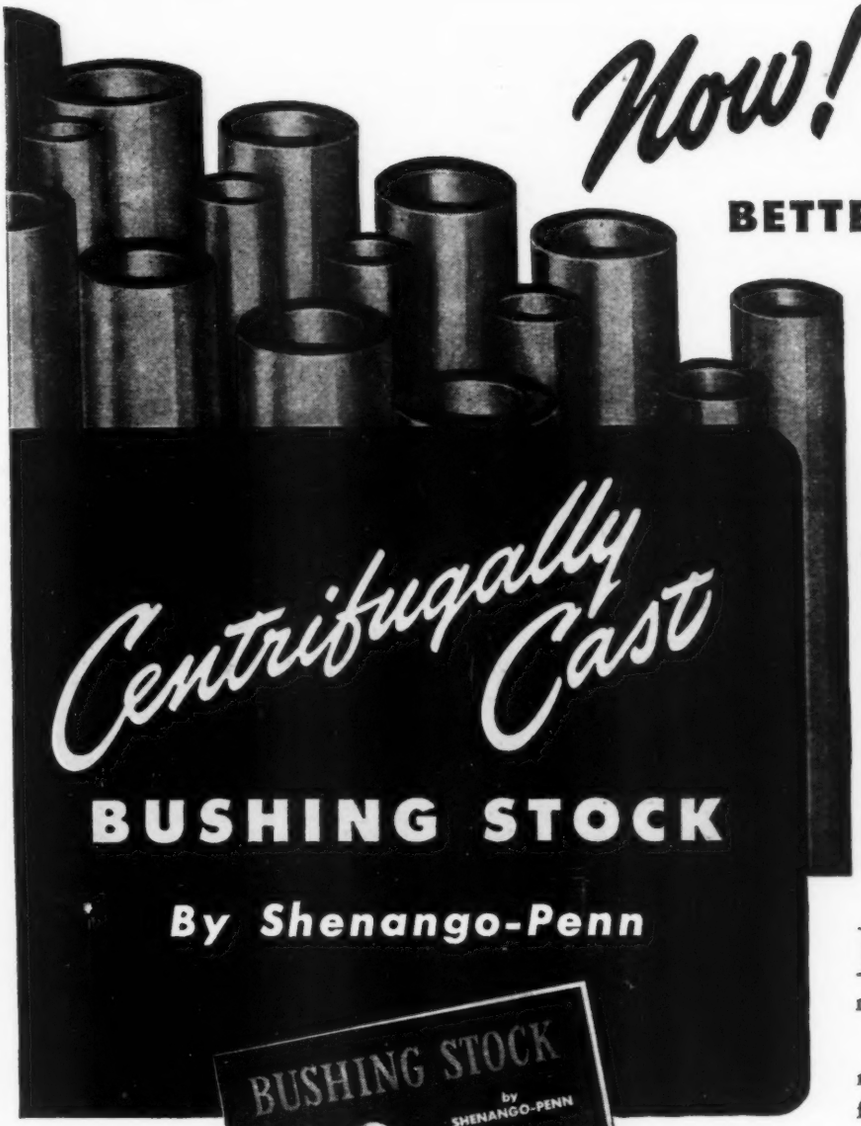
2.5 filament volts, peak inverse voltage as high as 10,000 volts, and a maximum average plate current of 0.25 amp. The 872A/872 has a 5 volt filament and carries a maximum peak inverse voltage rating of 10,000 volts and a maximum average current rating of 1.25 amperes.

Panel Lights

Jersey Technical Enterprises, 45 Clinton St., Newark 2, N. J.

Known as the Blink-O-Light, this device is a single-unit assembly including the automatic flashing mechanism removable lens, replaceable lamp, and





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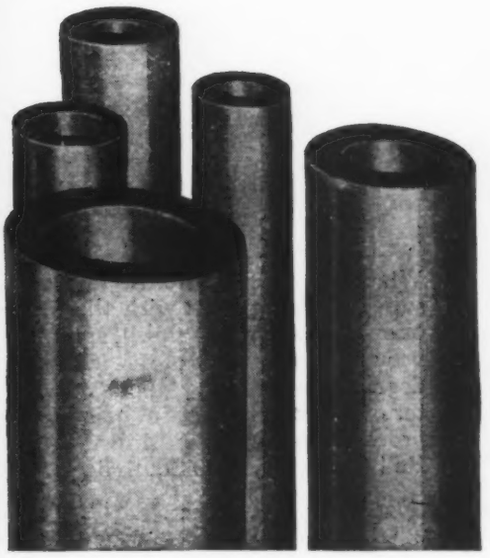

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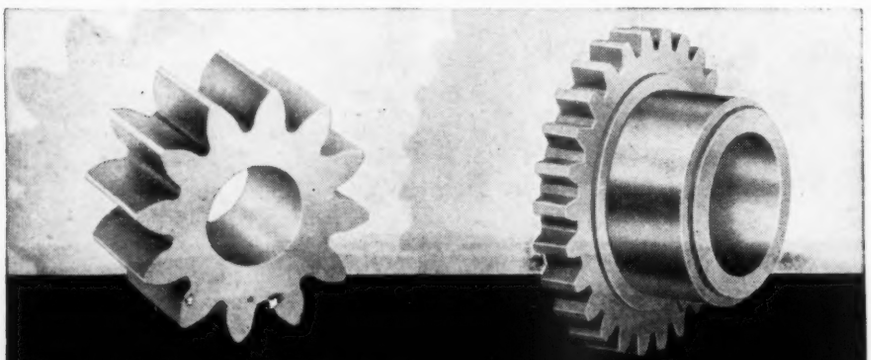

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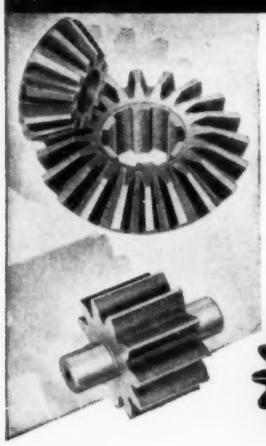

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socket. It is 3½ in. long and has a diameter of ¾ in. It requires one $\frac{11}{16}$ in. diameter hole for mounting, and a single terminal. It can be used in conjunction with any condition-responsive switch for warning of abnormal or dangerous conditions. Standard models are available for 6, 12, and 28 volts a.c. or d.c., and 115 volts a.c. These units can be arranged with test buttons for operation checking.

Rotary Pumps

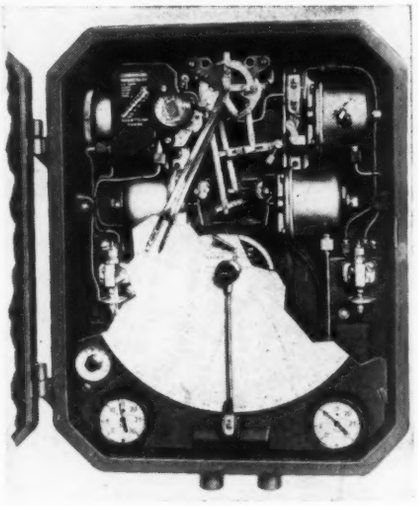
Ellipse Corp., Pump Div., 24 S. Clinton St., Chicago 6, Ill.

In the Series S-125 rotary pump, positive displacement ejection is obtained by mechanical action of vanes and rotor. The pump will deliver non-pulsing flow of oils, gases, and water, and will not be damaged by foreign matter. It is available with either flange or angle mounts. Tests, using 150 viscosity oil at 140 deg. F., show the capacity of the pump to be 2.5 gal. per min., at a pressure of 1,000 lb. per sq. in. The pump can also pull a vacuum of 26 inches.

Controls

Taylor Instrument Co., Rochester, N. Y.

A pneumatic transmission system, known as Transet, and used where long lead lines between transmitter and control panel are needed in the control of temperature, pressure, rate of flow, or liquid level. The controller regulates the control valve and transmits air pressure, proportional to the pen movement, to the indicating receiver. One gage of the receiver unit provides an indication of the controlled variable, the other gives an indication of the set pointer position. When both pointers of the receiver unit coincide, the process will be



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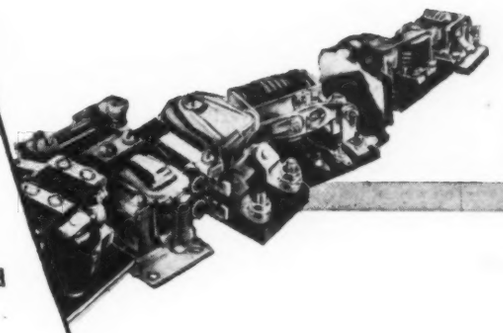

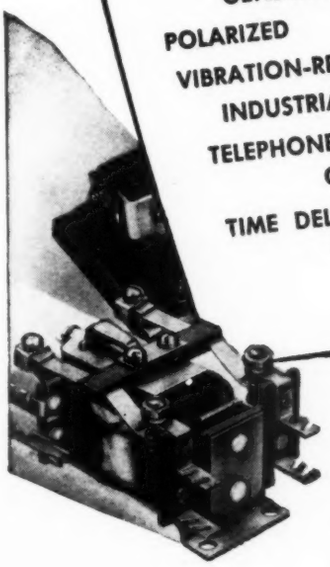

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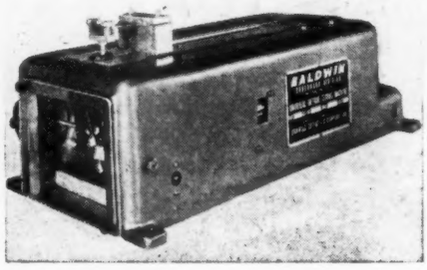
under control. Control is more exact because the controller can be located adjacent to the point of measurement cutting time lag to a minimum. The controller set pointer is pneumatically adjusted by the reducing valve on the receiver panel until pointer of the set gage is at the desired value.

Fatigue Testing Machine

Baldwin Locomotive Works, Philadelphia 42, Pa.

Known as the Sonntag SF-2, this bench-type testing machine does not need to be stopped and reset as the deflection of the specimen increases. This gives

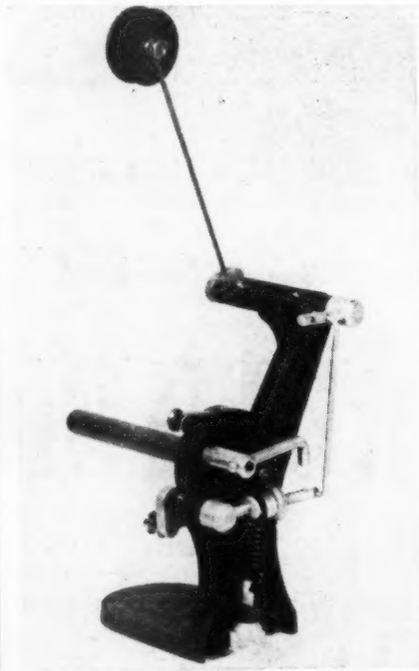


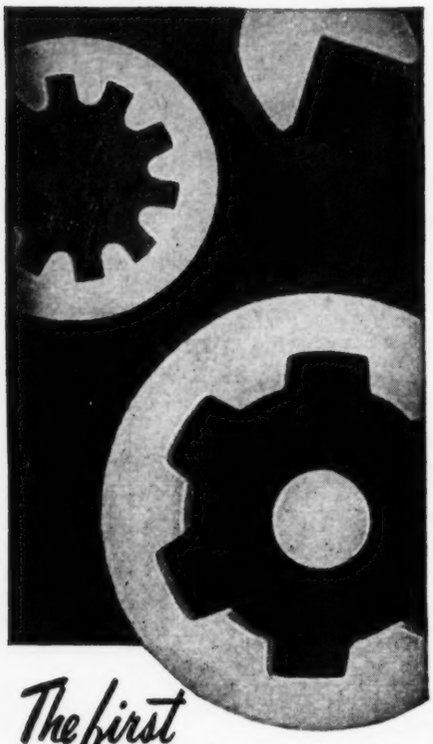
constant-force loading. The machine can be used for tests on sheet stock of any material; metal, plastic, or wood, and requiring no atention, can be run continuously on test.

Tension Device

Paper Machinery and Research, Inc., 1014 Oak St., Roselle, N. J.

Known as "Pamarco," this wire de-reeling tension device is claimed to keep constant tension while winding wire of





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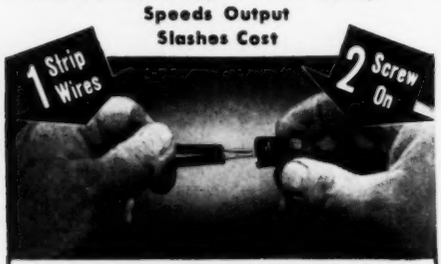

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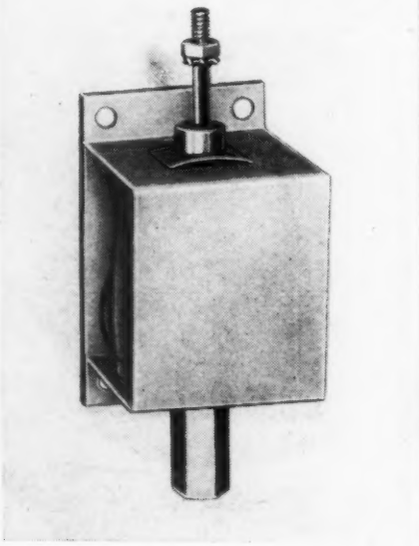
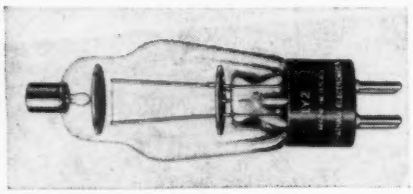


addition of side plates to the formed frame. This switch can be had for either push or pull operation. This switch has a work output of 1½ in. lb., continuous-duty basis, at 1 in. stroke.

Television Rectifier

Chatham Electronics, 475 Washington St., Newark 2, N. J.

Known as the 1Y2, this unit is a high voltage rectifier designed for anode supply on direct-view or projection-type television tubes. Peak inverse voltage rating is 50 kv. Filament voltage is not critical and can fluctuate between 1.0 and 1.65 volts. Interelectrode capacitance and absence of back emission prevents excessive loading of the oscillitory circuit in RF applications. Two tubes deliver 50 kv. d.c. in a voltage doubler circuit or 25 kv. d.c. single.



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